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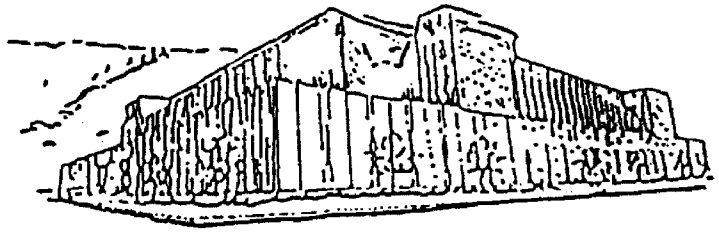
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BASELINE HYDROLOGICAL CONDITIONS, WILLOW CREEK BASIN,
VALLEY COUNTY, MONTANA

by

Jennie Jennings

B.S. Northern Montana College, 1990

presented in partial fulfillment of the requirements

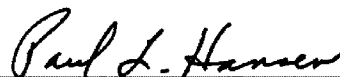
for the degree of

Master of Science in Resource Conservation

The University of Montana

1997

Approved by:



Chairperson



Dean, Graduate School

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Baseline Hydrological Conditions, Willow Creek Basin, Valley County, Montana

Director: Paul Hansen *PLH*

The Bureau of Land Management constructed eighty-nine detention reservoirs within the Willow Creek Basin between 1952 and 1972. Because of budget constraints the BLM can no longer maintain all of these structures. However, where necessary, channel restoration may be an option for maintaining the improved conditions within the basin. This study provides the baseline data necessary to determine any changes occurring to those channels above or below structures that are no longer functioning properly in the detainment of peak flows.

Three stream reaches above and three stream reaches below each of five reservoirs within the Willow Creek Basin were surveyed and permanently monumented using Rosgen's (1985) and Harrelson and others (1994) techniques. Of the thirty cross-sections surveyed three different Rosgen channel types were classified. There are sixteen C6, four F6, and ten G6 Rosgen channel types. Twelve of the sixteen C-type channels are located above the reservoirs, while nine of the ten G-type channels are located below the reservoirs. This finding indicates that the dams were indeed successful in preventing the advancement of the headcuts that were moving up the Willow Creek drainage.

The cross-sectional areas of the channels below the structures were not consistent with the findings of other research where the channel immediately below the impoundment had the greatest cross-sectional area while the channel farthest from the dam had a smaller cross-sectional area. The cross-sectional areas of some of the channels immediately below were smaller than those farther away. This is indication that structures placed in ephemeral and intermittent streams do not have the same effect on the channel as do structures in perennial streams.

Three alternatives are recommended to maintain the improved channel conditions within the basin. The alternatives to abandoning the reservoirs are, to construct check dams within the channel, reroute the channel to adjust for changes in slope above and below the dams, or to construct Rosgen B-type channels to compensate for slope differences in the channel above the dam and the channel below the dam.

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CHAPTER 1
INTRODUCTION
Background

Between 1952 and 1972 the Bureau of Land Management (BLM) constructed 98 structures (89 reservoirs and nine spreader dike systems) in the Willow Creek Basin, Valley County, Montana (figure 1). The purpose of these structures was to: 1) detain flows and reduce peaks from major flood events, 2) reduce sediment loads, and 3) reduce gully erosion (USDI 1985). The need to reduce sediment loads, erosion, and stabilize channels is still an objective of the BLM. However, since completion of the structures, Parrett (1986) indicates the more recent flood control structures around Glasgow and at the mouth of Willow Creek have eliminated the need for flood control in the Willow Creek Basin.

The highly alkaline soils of the watershed have corroded many of the dams' corrugated outlet structures. Unusually large amounts of sediment have resulted in complete siltation of several of the other reservoirs. Because of the high cost of these repairs and because of budget restrictions the BLM has elected to abandon all structures, except the few that are vital for road access to

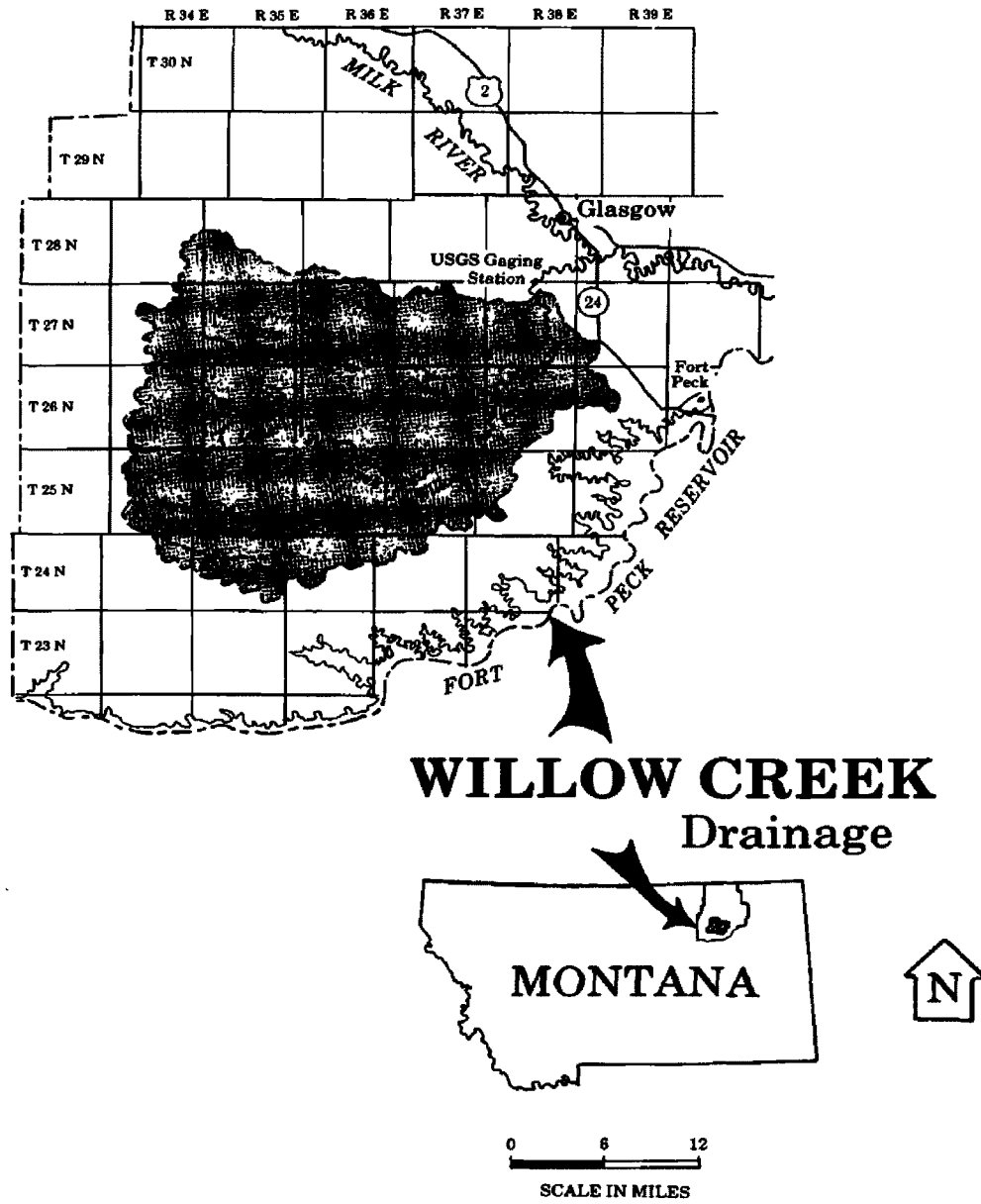


Figure 1. Location of the Willow Creek drainage (USDI 1985).

the basin. The only costs involved with abandonment would be those associated with resource mitigation such as revegetation, livestock watering facilities, and road reroutes (USDI 1985).

The BLM is a multiple-use agency and desires to continue providing access, resource protection, recreational opportunities, and livestock grazing in the basin. As the structures fail, providing these values presents the BLM with a difficult challenge for its future management of the basin. The BLM must retain as many of the benefits gained by the structures as possible, plus design management plans to mitigate the losses created by structure failures.

Objective

The objective of this study is to conduct a watershed assessment of the Willow Creek Basin using data collected in the field and from previous studies. This information will be used to measure the success of the initial Willow Creek project in detaining flows and reducing peaks from major flood events, reducing sediment loads, and reducing gully erosion. This baseline information will also be used by the BLM to help assess the effects of past, present, and future management practices.

Literature Review

Effects of Dams on Channel Morphology

Anything that alters the amount of sediment carried in a stream channel or the discharge of the stream will have an effect on stream channel morphology. "Throughout the world, river systems have been dramatically altered by human action. These changes have been induced directly by dams and reservoirs" (Petts 1984). Dams or instream structures alter both the sediment yield and the flow of a stream. Several studies have investigated the erosion that takes place immediately below dams caused by the removal of sediment (Leopold and others 1964; Komura and Simmons 1967; Gregory and Park 1974; Huang 1977; Petts 1980a & b; Grams 1991).

Research by Petts (1980a) has shown that there is induced erosion immediately below dams caused by the release of sediment-free water from the reservoir. However, according to Petts (1980b), this is only the first, most immediate response to dam closure. In the long-term, the redistribution of channel deposits and induced sedimentation will produce a channel of reduced cross-sectional area in response to the regulation of flows. In Petts (1980a) study of the channel below Camps Reservoir in Scotland, 50 years after construction, channel erosion has increased the cross-sectional area at bankfull stage to twice that expected. Yet, within 250 meters of the dam the channel capacity has been reduced by 50 percent.

Dunne and Leopold (1978) have also found that the removal of sediment from water flowing through reservoirs has caused extensive degradation of the channel. After the closure of the Hoover Dam on the Colorado River, there was extensive degradation of the channel for more than 160 kilometers (100 miles) downstream. The degradation was due to erosion of the bed and banks of the channel by the sediment-free water emerging from the dam. Dams with large storage capacities can trap 95 to 99 percent of the sediment that previously passed through the reach in which the dam is located (Leopold and others 1964).

The construction of a reservoir on Stony Creek, a tributary to the Sacramento River, has changed the reach below the dam from a braided channel to an incised, single-thread channel (Kondolf and Swanson 1993). Patton and Hubert (1993) have also found that the river downstream from Grayrocks Reservoir in Wyoming has changed from a braided system to one that is predominantly a single channel with a few remaining side channels and backwaters.

Huang (1977) studied the effects of channel changes below large impoundment structures. In his conclusions, he noted that the construction of a dam on an alluvial stream causes reductions in the downstream reach of the stream in: (1) the peak flows and in the frequencies of the high flows, (2) both suspended and bedload sediments, and (3) the percent of bedload to total sediment load. The stream responds to these changes by adjusting its slope

and channel geometry until a new equilibrium is achieved. According to Huang, changes of an alluvial stream in response to the degradation and the increase in roughness show that: 1) depth tends to increase, 2) velocity tends to decrease, 3) width-to-depth ratio tends to decrease at nearer sections, due to degradation, 4) channel capacity to transport water tends to increase at nearer sections, and decrease at farther sections from the dam, and 5) both suspended sediment and bed load transport capacities tend to decrease.

Gregory and Park (1974) have studied the effects of flow regulation on the channel above and below Clatworthy Reservoir in Somerset, England. Fourteen cross-sections above the dam and 15 cross-sections below the dam were surveyed to determine channel capacity. Immediately below the dam the cross-sectional areas for the 15 sites surveyed have been reduced by 54 percent of their expected level. Farther downstream, channel capacity increased until values of channel capacity were comparable with other values indicated from above the reservoir. Peak discharges with 1.5- and 2.33-year recurrence intervals were deduced to be about 40 percent of the discharge prior to reservoir construction. Therefore, Gregory and Park have concluded that reduction of channel capacity accompanies a reduction of peak flows.

Previous Research of the Willow Creek Basin

Various studies have been completed on the Willow Creek Basin in the last 30 years. The research ranges from the effects of the structures on runoff

and sediment yield within the basin to vegetation changes due to grazing and climate. A brief review of some of the research follows.

Runoff and sediment yield have been affected by the construction of the Willow Creek structures. However, without any hydrological data before the structures were in place, the magnitude of the effects cannot be compared. Frickel (1972) used runoff data collected by the U.S. Geological Survey in the 1960s to estimate that the conservation structures decreased the peak discharge of a large flood in 1962 by about 45 percent. At the Willow Creek gaging station, located at the lower end of Willow Creek, approximately 64 kilometers (40 stream miles) below Collins Reservoir, the width of the channel has narrowed significantly since 1955 (figure 2).

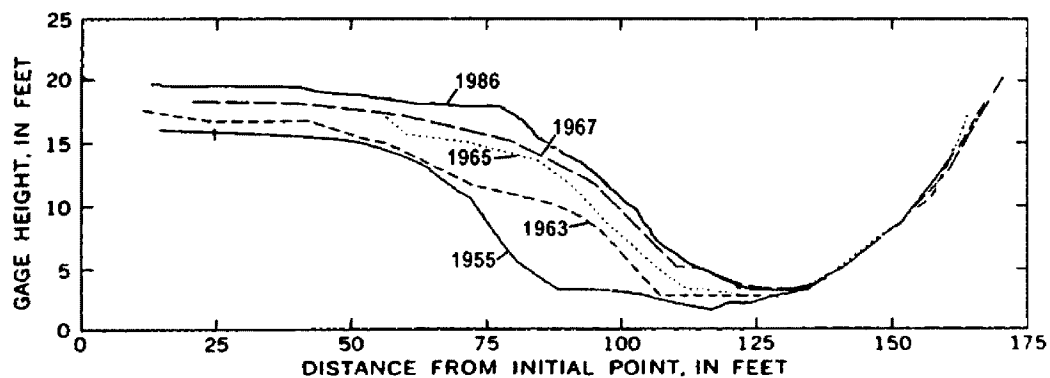


Figure 2. *Channel cross-section at Willow Creek gaging station (Frickel 1972).*

This change is probably the result of reduced peak discharges and reduced flows brought about by the detention reservoirs and the hundred retention livestock ponds within the basin.

Parrett (1986), using the Hydrologic Engineering Center-1 (HEC-1) runoff simulation model, estimated that the cumulative effect of all structures in the Willow Creek Basin is a seventy-four percent decrease in the 100-year peak discharge at the mouth of the basin. The first simulation, with no structures in place, calculated the 100-year-frequency peak at the mouth of Willow Creek to be 22,700 cfs. With all structures in place the 100-year-frequency peak was estimated to be 5,870 cfs (figure 3).

The structures have also been successful in reducing the sediment loads. According to Frickel (1972), suspended-sediment concentrations at the gaging station were reduced about 55 percent during an 11-year period. The computed estimate of sediment yield, from the average uncontrolled area for the period 1954-1965, is 507 acre-feet per year. The sediment yield measured at the gaging station was 500 acre-feet per year. By using vegetation types to estimate sediment yield, Frickel determined that the basin produced an average of 751 acre-feet per year resulting in 251 acre-feet of sediment being trapped by the reservoirs each year.

Branson and Miller (1981) completed a study to determine the effects of grazing and climate change within the basin. Upland and lowland plant communities were sampled in 1960 and again in 1977. The plant communities

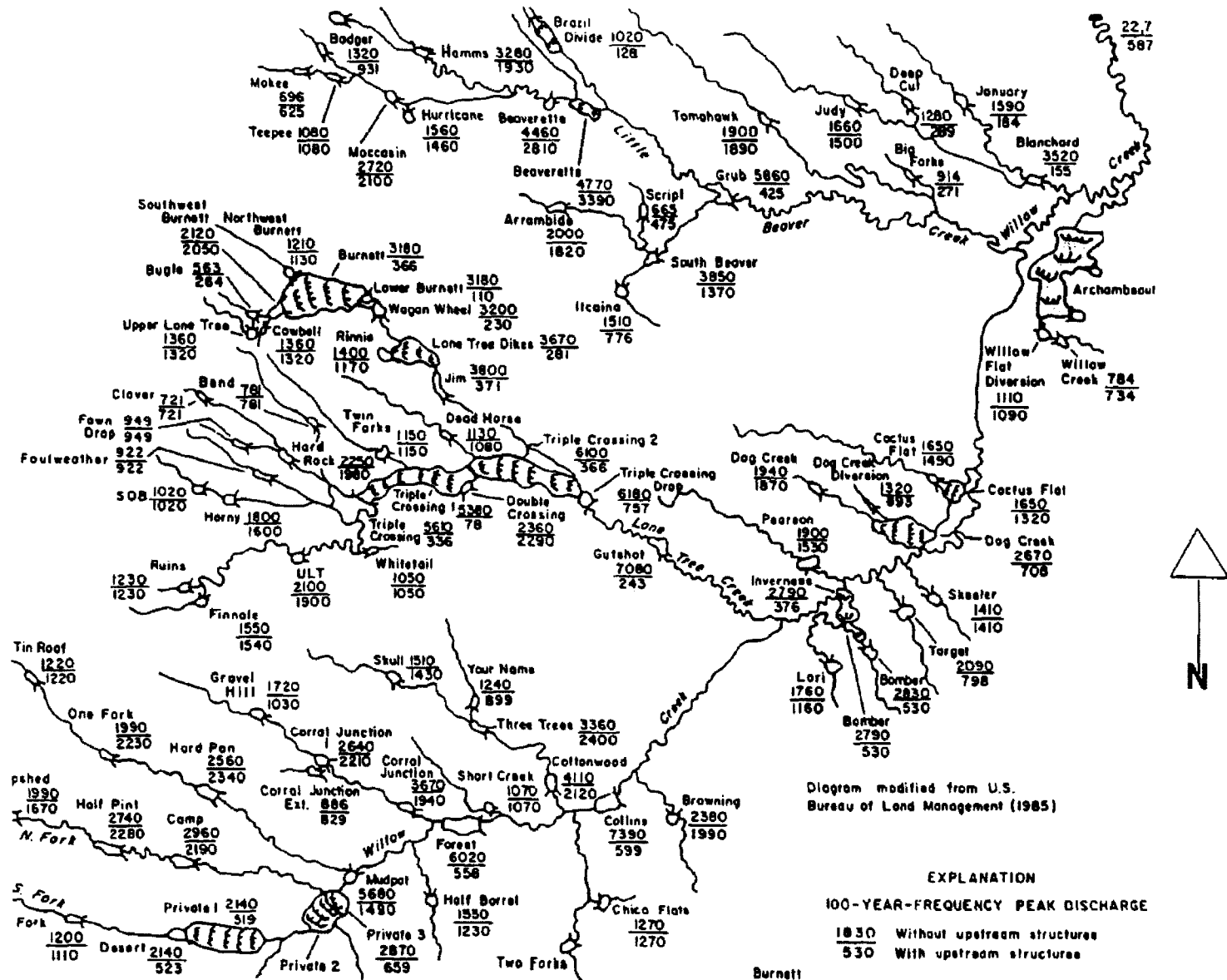


Figure 3. Schematic diagram showing 100-year frequency discharges, in cfs, of the Willow Creek structures (Parrett 1986).

included *Artemisia tridentata* (big sagebrush), *Atriplex nuttallii* (nuttall saltbush), *Sarcobatus vermiculatus* (greasewood), *Agropyron smithii* (western wheatgrass), *Artemisia cana* (silver sagebrush), buckwheat, annual forbs, and mixed shrubs. Of the 15 communities monitored, 13 showed marked improvement during the 17-year period, with grasses and mulch showing consistent and large increases in all communities. Branson and Miller attributed the improvement to two factors: 1) changes in management practices (reduced grazing intensities, grazing distribution, contour furrowing), and 2) higher average annual precipitation during the period following the first sampling.

In 1985 Miller (1987) expanded on the research he and Branson completed earlier. His report discusses the influence of hydrologic properties of soils on the type and amount of range vegetation. In addition to collecting soil samples, the same plant community sites that were counted in 1960 and 1977 were reinventoried. Both shrubs and grasses increased considerably from 1960 to 1977. In 1985-86, after a period of drought, shrubs showed a slight increase while grasses decreased. Yet, the amount of grass cover in 1985-86 was still much greater than in 1960, before the implementation of any grazing systems.

CHAPTER 2

STUDY AREA

Willow Creek, an intermittent stream, drains an area of about 1,416 square kilometers (547 sq. miles) in northeastern Montana. The Creek flows northeastward to join the Milk River about 4.8 kilometers (3 miles) southeast of Glasgow, in Valley County (figure 1, page 2).

Tributary stream channels are deeply entrenched and are actively eroding, thus contributing much sediment directly into the main channel. The average gradient of Willow Creek from the confluence of its South and North Forks to the Milk River is 0.85 meters per kilometer (4.5 feet per mile). The elevation of the basin ranges from 610 meters (2,000 feet) to about 850 meters (2,800 feet) above sea level. The immediate study area includes five sub-basins within the Willow Creek Basin (figure 4). The total drainage area of the five sub-basins is approximately 324 square kilometers (125 sq. miles). It is a fifth order drainage basin with approximately 724 kilometers (450 stream miles). The stream reaches surveyed are all on the main Willow Creek channel and are located above and below each of five reservoirs. The reservoirs, Sheepshed, Camp, Mudpot, Forest, and Collins, were constructed between 1954 and 1957.

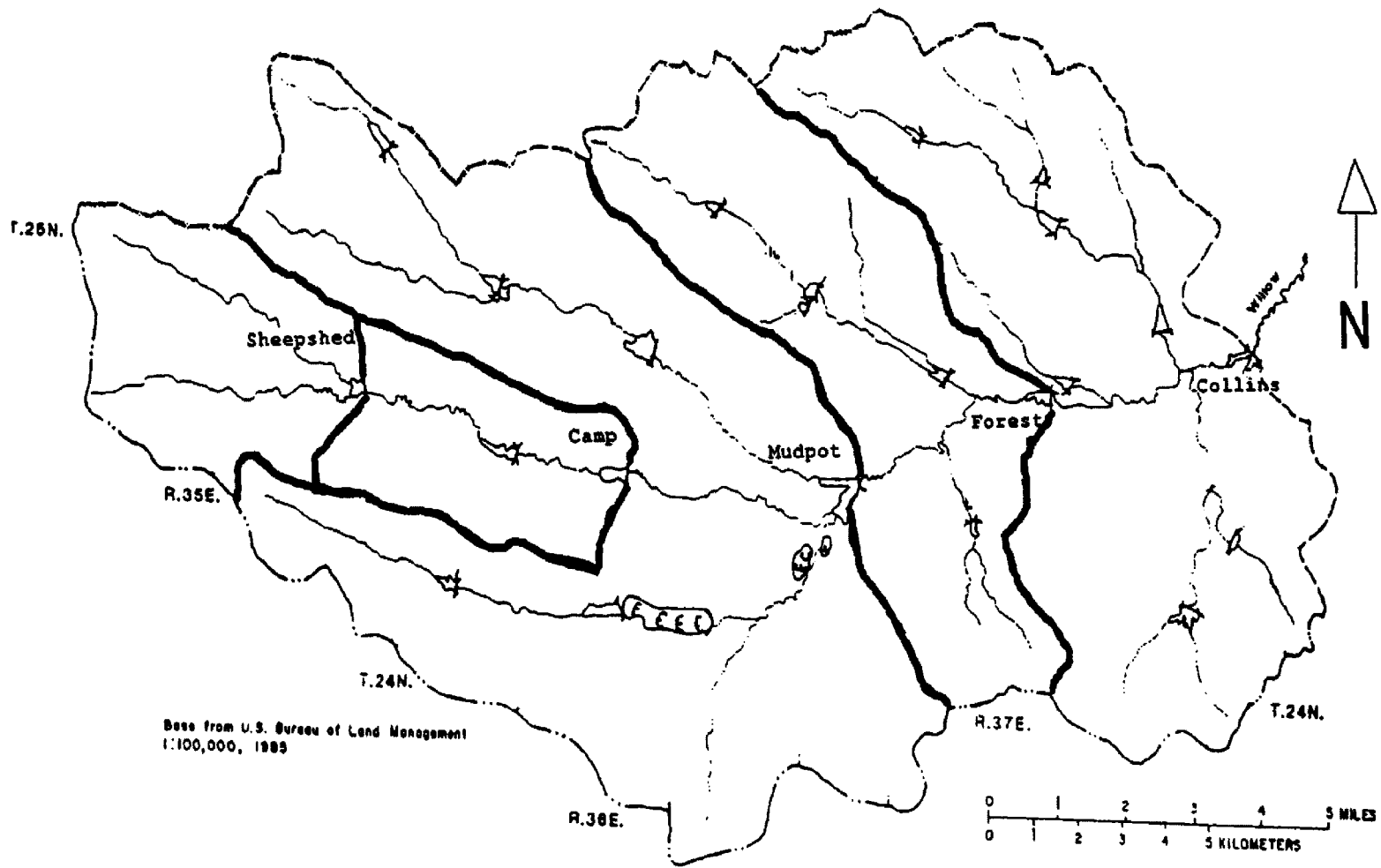


Figure 4. Subbasin boundaries within the Willow Creek Basin.

Camp and Collins, which were built at the site of major headcuts, have failed on more than one occasion since the time of their initial construction. Sheepshed, Mudpot, and Forest have been functioning properly, by detaining flows, since the date of their completion.

Land Use

Approximately 87 percent of the land in the Willow Creek Basin is managed by the Bureau of Land Management. Seven percent is privately owned, and six percent is state owned. The basin is primarily used for grazing, forage production, and wildlife habitat. A predominance of highly alkaline soils limit farming in the basin (USDI 1985).

Until 1976, grazing by livestock in the basin was either season long or year long. After 1976 the BLM implemented deferred and rest rotation grazing systems. Deferred grazing involves the use of two or more pastures. Every year livestock are rotated through each pasture, one pasture is grazed, while the others are rested. With the deferred rotation system every pasture is used at least once each grazing season. Rest rotation involves the use of two or more pastures. One or more of these pastures is rested the entire year, while livestock are rotated through the remaining pastures. When all pastures have been rested at least one year, the cycle begins again.

Either rest rotation or deferred grazing is in operation above and below all of the reservoirs in the study, with the exception of Collins. The pastures above and below Collins Reservoir are holding pastures, which means that the cattle are only there for a short time in the fall before being transported.

During the time of record, from around 1960 to the present, livestock numbers have remained relatively constant throughout the study area. What has changed, however, are the season, duration, and type of use within each allotment.

All of the cross-sections surveyed are within five separate allotments in the area. Rest rotation and deferred grazing methods have been in use in allotments 4584, 4590 and 4591 for the past 20 years. The deferred rotation (DR) system in allotment 4589 has been implemented for the past ten years and the rest rotation (RR) system has been used in allotment 4595 for the past four years. Table 1 contains each allotment within the study area and lists acres/aum, season of use, and grazing methods.

Table 1. *Grazing use by livestock within the study area.*

Allot no.	cross-sections within allot.	Ac/ Aum	From	to	grazing method
4584	Collins 2-6	9.6	not specified	not specified	spr/fall
4589	Mudpot 1-3 Camp 4-6	8.0	5/1	10/04	DR
4590	Forest 1-6 Mudpot 4-6	13.3	4/1	10/30	RR
4591	Collins 1	4.4	not specified	not specified	spr/fall
4595	Camp 1-3 Sheepshed 1-6	9.2	4/1	10/30	RR

Geology and Soils

The regional geology of the Willow Creek basin within the Fort Peck area consists of gently dipping Mesozoic and Paleozoic sediments overlying Precambrian crystalline basement rocks. The approximate thickness of sedimentary sequence is approximately 2,100 meters (7,000 feet). Remnants of Pleistocene glacial deposits and Tertiary alluvium and landslide deposits are present in some areas.

At least two advances of the sea took place in this area during the Late Cretaceous period. The first advance deposited the Claggett shale; the second advance is represented by the thicker Bearpaw shale. The Bearpaw shale is

exposed throughout the Fort Peck area except for about 31 square kilometers (12 square miles) in the southern part and in the extreme northeast corner where it is overlain by the Fox Hills sandstone (Jesen and Varnes 1964).

The Bearpaw shale, a black marine shale high in sodium, has an average thickness of 347 meters (1,140 feet). The formation consists of dark gray clayey shale with bentonite found both in distinct beds and disseminated throughout much of the shale. Where bentonite is absent, the shale weathers into small, soft chips. The chips are easily removed by sheet wash but may form a weathered zone several meters thick when not removed by erosion. Where bentonite is present, the shale weathers into a hard, foot-thick rind. The rind swells when wet and shrinks when dry to form abundant cracks varying in depth from a few centimeters (one inch) upwards to two meters (six feet). The deep cracks allow appreciable channel slumping and headcutting during runoff periods. The prevalence of bentonite and other clay minerals in the shale formation also creates a high runoff environment within the Willow Creek Drainage (USDI 1985).

The Fox Hills sandstone is of Latest Cretaceous age and reaches a thickness of as much as 36 meters (120 feet) in the Fort Peck area. The lower 10 to 12 meters (35 to 40 feet) is made up of beds transitional from the underlying Bearpaw shale to the overlying sandstone. The lower part of the Fox Hills is composed of noncalcareous thin beds of alternating soft claystone,

siltstone, and very fine sandstone, with the finer grained beds predominating near the base (Jensen and Varnes 1964).

Ground moraine of Pleistocene age Wisconsin glaciation may have covered the entire Fort Peck area, but postglacial erosion has stripped it from major valleys and from the hilly belt of shale and sandstone in the southern and southwestern parts of the area.

The Kintyre formation, composed of fluviolacustrine silt and fine sand and clay, overlies the ground moraine in some parts of the Milk and Missouri River valleys. The Kintyre formation was deposited on stagnant ice of the wasting Wisconsin glacier. Glacial outwash is limited to widely separated deposits in the rolling prairie upland and to terrace deposits (Jensen and Varnes 1964).

Three physiographic landscapes occur in south Valley County: 1) sedimentary uplands, 2) glaciated uplands, and 3) floodplains and terraces. The sedimentary uplands are comprised of mostly Lisam and Thebo soils. The Lisam series consists of shallow, well-drained soils formed in materials weathered from clay shale. Bedrock is reached at a depth of about 30 centimeters (12 inches). Surface runoff with the Lisam series is rapid. The Thebo series consists of moderately deep, well-drained soils also formed in materials weathered from clay shale. The soil is 60 to 75 percent clay (USDA 1984).

The glaciated uplands include Phillips, Scobey, and Telstad soils. These soil series consist of deep, well- drained soils that formed in glacial till. Surface runoff is moderate (USDA 1984).

The floodplains and terraces consist of alluvium with Vaeda clay soils comprising most of this landscape. The Vaeda series consists of deep, well- drained soils that formed in alluvium. Slopes range from 0 to 5 percent. Permeability is very slow. The available water capacity is low or moderate. Vaeda soils have a high content of sodium (alkali) and intake of water into the soil is restricted.

The stream channels are made up of Typic Fluvaquents and Ustic Torrifuents. Typic Fluvaquents are nearly-level and gently-sloping soils that formed in alluvium on flood plains, in oxbows, in abandoned stream channels, and on stream terraces. Their surface layers and underlying materials range from loam to clay. Most of these soils are poorly drained and flooding is frequent.

Ustic Torrifuents consist of soils that formed in recent deposits of alluvium on nearly-level to gently- sloping low terraces, bottom lands, and flood plains. Soils are mostly well drained and moderately well drained but are subject to common flooding. The soil is stratified loam to clay. The Ustic Torrifuents found in the Willow Creek Basin have little or no gravel in the soil. Soils that are high in clay are strongly alkaline (USDA 1984).

Drainage Development

Prior to the last glacial advancement in northeast Montana of the Wisconsin age, the ancient Willow Creek flowed east, joining the Missouri River below the present day Fort Peck Dam. Advancing from the north, a regional ice sheet was divided into lobes which were directed west. One lobe moved up the Milk River and another moved up the Missouri River, each forming ice dams and backing up water along the way. At this point the divide between the Milk River and Willow Creek was overtopped by backwater from the Milk River, eroding a spillway through the soft Bearpaw shale. Meanwhile, the Missouri River ice lobe dammed the ancient Willow Creek channel causing backed water from Willow Creek to eventually cut a new spillway draining into the Milk. As the Milk River ice lobe receded, Willow Creek established itself in this new, steeper valley (figure 5) (Jensen and Varnes 1964).

Another geologic phenomenon that been responsible for the deep incision of Willow Creek and its tributaries, is that, as the ice regressed, the river bottoms of the Milk River and the Missouri River gradually aggraded, affecting principal tributaries such as Willow Creek. Wide alluvial terraces were built up in the Willow Creek valley bottoms as the river beds continued building. In recent geologic time, the down cutting regime has resumed and has since lowered the

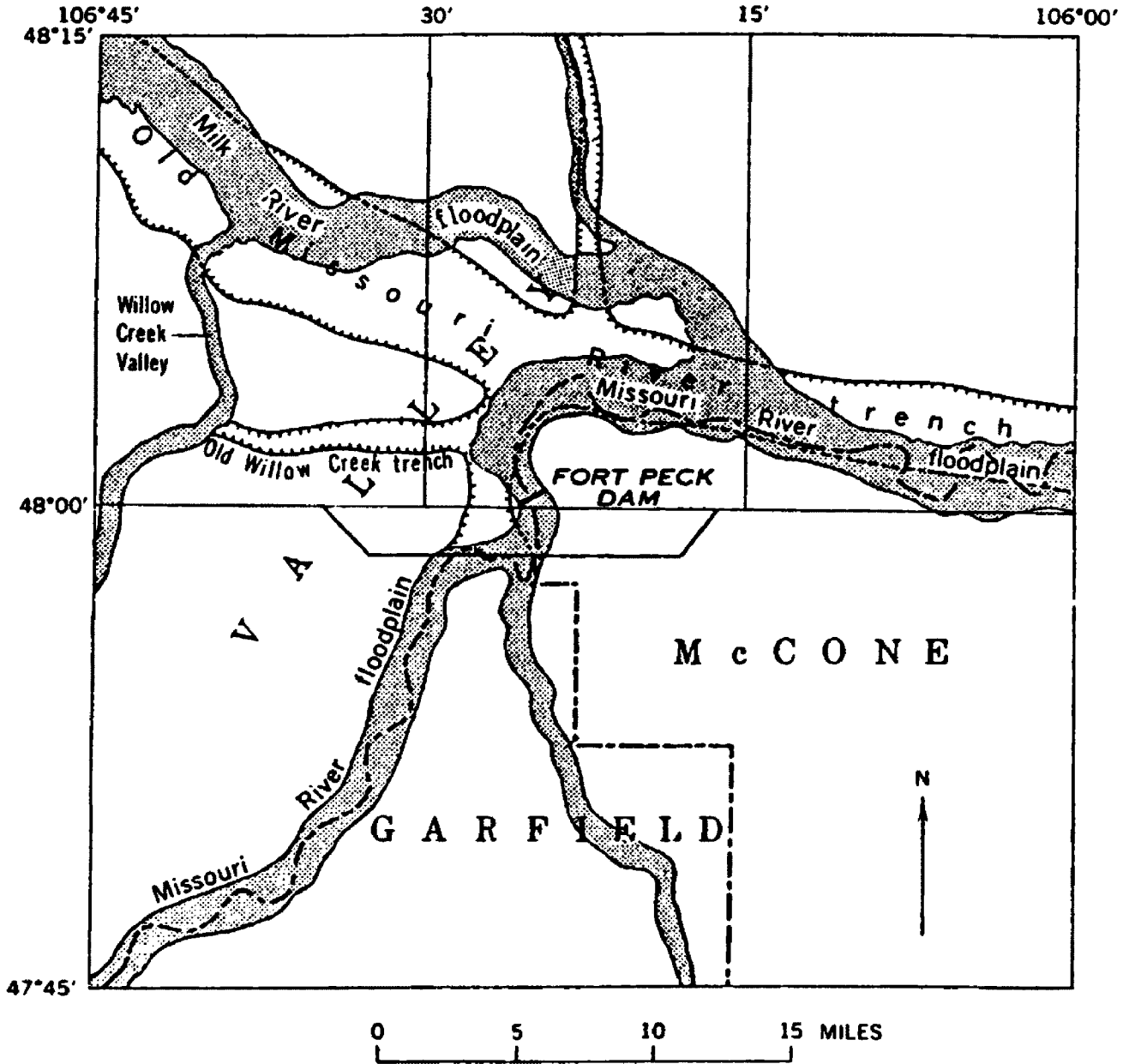


Figure 5. Map showing old Willow Creek trench (Jensen and Varnes 1964).

floodplain about 7.6 meters (25 feet). Again the effect was felt in the tributaries and Willow Creek began cutting channels throughout the alluvial terraces (Jensen and Varnes 1964).

Vegetation

Vegetation in the basin is separated into four lifeform categories: trees, shrubs, graminoids and forbs. Tree species consist of *Salix amygdaloides* (peach-leaf willow), *Populus deltoides* (Great Plains cottonwood), and *Acer negundo* (boxelder).

Shrubs found in the basin consist of *Artemisia cana* (silver sagebrush), *Artemisia tridentata* (big sagebrush), *Artemisia frigida* (fringed sagewort), *Sarcobatus vermiculatus* (greasewood), *Salix lutea* (yellow willow), *Salix exigua* (sandbar willow), and *Rosa woodsii* (woods rose).

Graminoids and forbs consist of *Atriplex nuttallii* (nuttall saltbush), *Agropyron smithii* (western wheatgrass), *Agropyron trachycanum* (slender wheatgrass), *Calamagrostis montaensis* (plains reedgrass), *Carex eleocharis* (needleleaf sedge), *Hordeum jubatum* (foxtail barley), *Poa secunda* (sandberg bluegrass), *Stipa viridula* (green needlegrass), *Bouteloua gracilis* (blue grama), *Sitanion hystrix* (bottlebrush squirreltail), *Stipa comata* (Needle-and-thread),

Rumex sp. (dock), *Selaginella densa* (clubmoss), *Optuntia polycantha* (plains pricklypear), *Eleocharis palustris* (common spikesedge) and *Xanthium commune* (common cocclebur) (Branson and Miller 1981; Miller 1987; USDI 1985).

Climate

The climate in the Willow Creek Basin is semi-arid continental. Average temperatures range from -8 degrees Celsius (17 degrees Fahrenheit) in January to 29 degrees Celsius (85 degrees Fahrenheit) in July. Record low for the thirty year period of record was -43 degrees Celsius (-47 degrees Fahrenheit) in January and a record high of 41 degrees Celsius (108 degrees Fahrenheit) in July. The average precipitation from data collected at four stations in the surrounding area (Glasgow, Fort Peck, S. Malta, and Brussett) is 30 centimeters (12 inches), based on 35 (1953-1987) years of National Weather Service (U.S. Department of Commerce 1995) records. Over sixty percent of the precipitation falls during the months of May, June, July, and August, with most of this falling in June (figure 6).

Willow Creek Area average monthly precipitation (1953-1987)

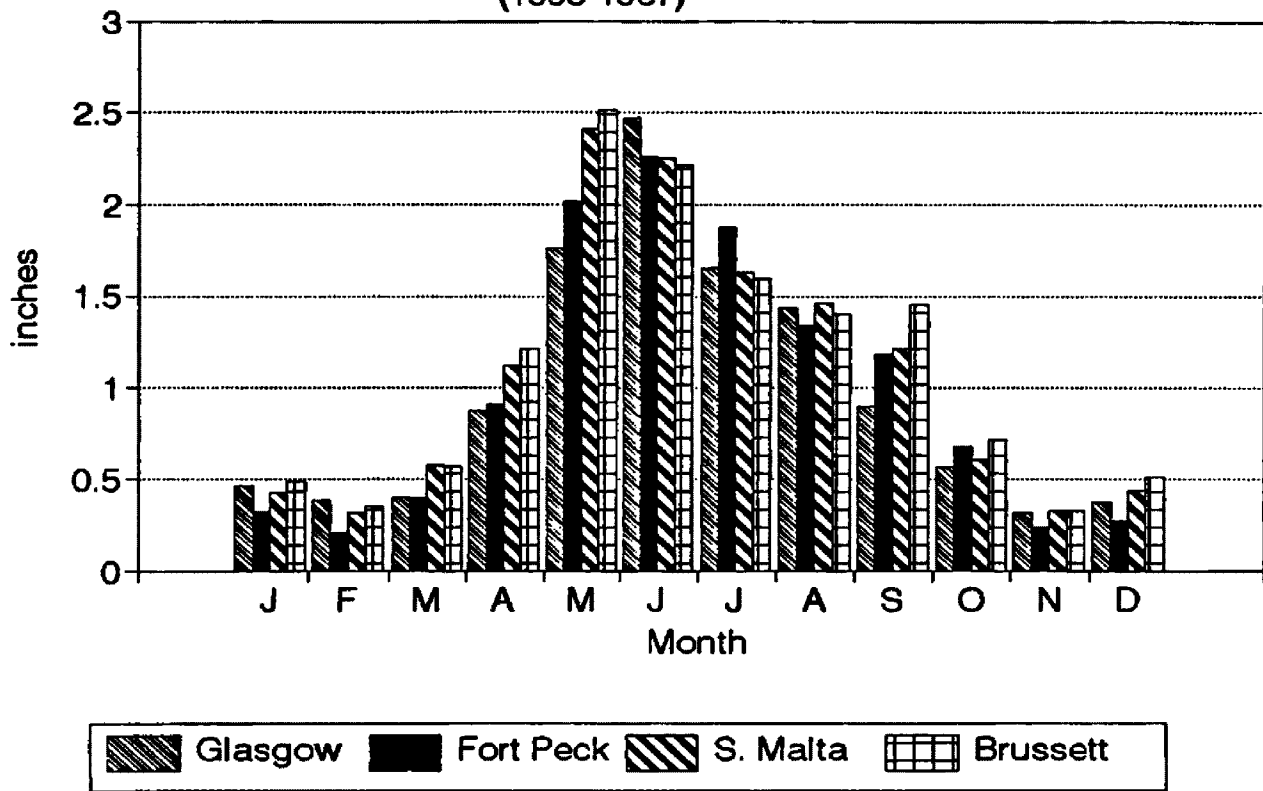


Figure 6. Average monthly precipitation (1953-1987) for the area surrounding the Willow Creek basin.

CHAPTER 3

METHODS

Data was collected in the field to determine channel type and health and function of the riparian vegetation. To determine condition of the uplands, I relied on literature from previous studies of the basin (Branson and Miller 1981; Miller 1987) and upland vegetation inventories conducted by the BLM, Valley Resource Area.

Several studies and reports have been conducted on the effectiveness of the Willow Creek structures on decreasing flood flows, decreasing sediment yield, and increasing vegetation in the basin (Chapter 1). These studies discuss the vegetation, sediment yields, and stream flows within the basin, but none of them include channel assessment, a necessary component to understanding the hydrologic processes within the watershed.

Research began by examining all studies previously done in the Willow Creek Basin. A second literature search was conducted in order to compare methods and results of similar studies and research. In addition to this information, project files detailing site location of the dams and dam descriptions

were obtained from the BLM's Valley Resource Area; this information was used for descriptive purposes only. Allotment files of the area were also collected to compare the grazing practices within the study area.

Topographical maps (1:24,000) of the basin were used to delineate the watershed. After outlining the sub-basins within the watershed, the area of each was determined using a TAMYA-planix 5000 planimeter. Stream miles and drainage basin order were also measured from the 1:24,000 topographical maps.

Because no historical data in which complete channel cross-sections were surveyed exists channel changes, over time, cannot be determined quantitatively. There are, however, aerial photos taken of the area before and after the structures were constructed and, according to Rosgen (1994), observations can be made of progressive stages in channel adjustment by reviewing historical aerial photos.

The Riparian Wetland Research Program (RWRP) inventory method, developed by Hansen and others in cooperation with the BLM and other government agencies, was used to determine the health and function of the riparian areas and their vegetative habitat types. The RWRP method uses a form requiring the collection of sixty-five data elements. Data elements are obtained by physically walking the stream channel and associated riparian areas. Thirteen of these data elements were then used in the health and function

evaluation. The RWRP health and function evaluation places the stream into one of three conditions, based on a scoring system (percentage) determined by dividing the actual score by the total possible score. These conditions are proper functioning condition (80 - 100 percent), functioning at risk (60 - 79 percent), and non-functioning (<60 percent).

Proper functioning condition is defined as riparian-wetland areas where there is adequate vegetation, landform, or large woody debris present to dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality, filter sediment, capture bedload, and aid floodplain development.

Functioning at risk is defined as riparian-wetland areas that are properly functioning. However, a soil, water, or vegetation attribute makes them susceptible to degradation and lessens their ability to sustain natural biotic communities.

Non-functioning is defined as riparian-wetland areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows and thus are not reducing erosion, improving water quality, or other normal characteristics of water quality. The absence of certain physical attributes, such as a flood-plain where one should be, are indicators of non-functioning conditions (USDI 1993).

In 1990 the RWRP inventoried seven polygons on upper Willow Creek. These same polygons were again inventoried in 1996 for comparative purposes. By comparing the two sets of data, trends which may indicate success or failure of present management practices can be determined. In addition to the RWRP inventories, aerial photos were studied to determine changes in vegetation. The photos were of three different time periods: 1949, 1953, and 1981.

Stream channels above and below five reservoirs located on the main channel of Willow Creek were classified using Rosgen's (1985) classification system. There are other classification systems in use, such as Montgomery and Buffington (1993), Schumm (1963), Dunne and Leopold (1978), and Pfankuch (1975), but Rosgen's classification system was used because of its use throughout the Bureau of Land Management and other government agencies, such as the U.S. Forest Service.

Using Rosgen's (1985) classification system, three reaches above and three reaches below each reservoir were surveyed for cross-sectional information. Each reach was at least one meander length in distance or twenty times the width of the channel. The cross-section was surveyed on a straight segment between the two bends on the meander in a riffle area.

Elevation of bankfull and cross-section profile were measured using a survey level and rod, distances were measured using a 30 meter (100 foot) tape.

Station elevations and distances were taken at each change in slope, bankfull, twice bankfull, and edge of water. Where evident, measurements were also taken at high water marks and vegetation changes. Each cross-section was monumented using the techniques described in Harrelson and others (1994) guide to field technique. The beginning and ending points of each cross-section were recorded using a Geoexplorer II GPS unit, and are listed in Appendix C. Also listed are the measured widths and depths of each cross-section.

Channel slope was determined by surveying the elevation at the edge of flowing water, upstream and downstream, from the benchmark location. The elevation at the upstream point was subtracted from the elevation at the downstream point. The difference between the two numbers was then divided by the channel length. Sinuosity was calculated from aerial photos; the length of the stream segment was measured and divided by the valley length for that stream reach. The data obtained by surveying these cross-sections was used to classify the stream reaches according to the Rosgen classification system (figure 7).

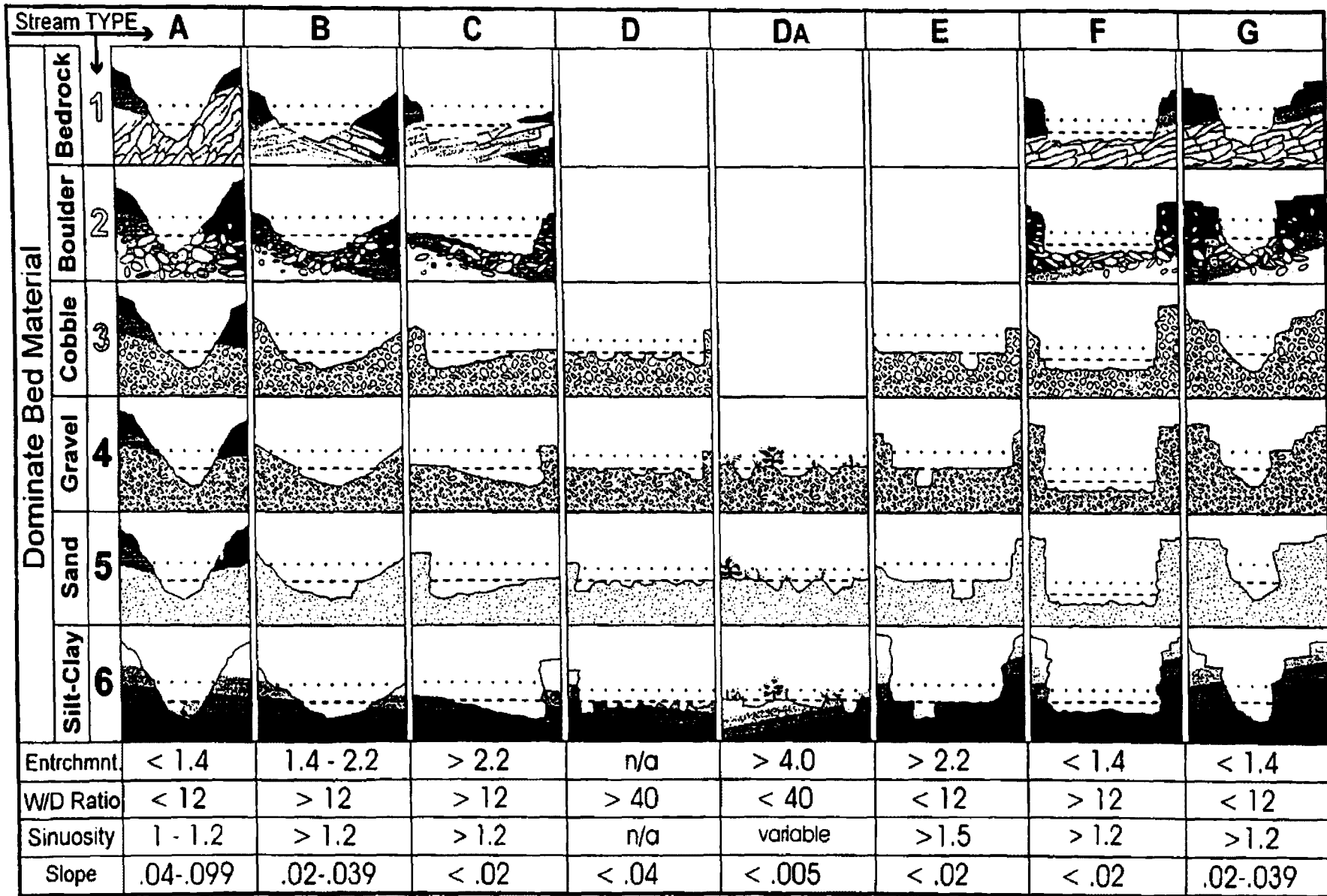


Figure 7. Delineative criteria for the different Rosgen stream types (Rosgen 1996).

CHAPTER 4

RESULTS AND DISCUSSION

The objective of this study was to conduct a baseline watershed assessment of the Willow Creek basin. However, it was impractical to do channel assessment on all 724 stream kilometers (450 stream miles) within the study area. For this reason, I chose three stream reaches above and three below each of five reservoirs located on the main Willow Creek channel to represent all 724 stream kilometers (450 stream miles). These reaches can then be resurveyed, in subsequent years, to determine the impacts the structures have had upon the channel.

Using Rosgen's (1985) classification, system 30 stream reaches were surveyed to determine channel type. The stage, or elevation, of bankfull discharge is the single most important parameter used in stream channel classification (Rosgen 1996). Bankfull, considered to be the channel forming flow, is the flow which just fills the channel to the tops of the banks, and is an integral part of Rosgen's classification system. This measurement is needed to determine the width-to-depth ratio and entrenchment of the channel, two of the four delineative criteria for determining channel types. The width-to-depth ratio is

the ratio of bankfull width to the mean bankfull depth and is an indicator of channel cross-section shape. The entrenchment ratio is the width of the flood-prone area at an elevation that is twice that of the maximum bankfull depth. The entrenchment ratio describes the degree of vertical containment of the river channel (Rosgen 1996).

Indicators of bankfull include the top of a point bar, change in vegetation, change in slope or change in size distribution of materials at the surface (Leopold 1994). Unfortunately, the bankfull indicator is difficult to ascertain in ephemeral and intermittent streams, especially those that have been altered by instream structures, such as Willow Creek. Often there were no discernable changes in any of the above indicators. For this reason, what was determined to be bankfull elevation may not have been the true bankfull. This would impact entrenchment and width-to-depth ratios and could change the delineated channel type. Rosgen developed his classification based on measurements from perennial stream systems, none of which were located in eastern Montana. Because of this, failure to consistently find a bankfull indicator, or picking the wrong one, in an ephemeral or intermittent system such as Willow Creek, tends to call a stream reach an "E" or "F" when it is really a "G" channel. Where there were discrepancies in channel type according to the measured criteria the shape of the cross-section was used to classify the Rosgen channel

type. In those channels, such as the ones below Collins, using only the measured criteria the reaches could be classified as either a Rosgen E or G channels. Yet, by studying the cross-sectional profiles it was noted that these channels lacked the well-developed floodplain of an E channel. For this reason the reaches were determined to be Rosgen G-type channels.

Although channel stability is associated with channel type, and channel type depends on bankfull determination, it is important to keep in mind that the benefit in the classification is its reproducible and quantifiable data and the frame of reference it provides for communication (Rosgen 1996).

Of the 30 channel reaches surveyed in the study area, I found three different channel types according to Rosgen's classification (Appendix A-1 through A-5). These are C6, F6, and G6 channel types. A C-type channel is defined as being wide and shallow with a well developed floodplain and a broad valley; the F-type channel is also wide and shallow but is an entrenched meandering channel with little to no developed floodplain; G channels have a low width-to-depth ratio similar to E streams, except they are well entrenched, have no floodplain, and are steeper and less sinuous than E streams (Rosgen 1996).

Several studies have been conducted to determine the effects dams have on the channels below them. Examples of these same studies are mentioned in the literature review in Chapter 1. The findings of the research mentioned above

were consistent in that immediately below the structures degradation of the channel occurred, and farther from the dam the channel capacity begins to decrease. Degradation of the channel is attributed to scouring of the channel banks by the 'sediment free' water flowing from the structures. The decrease of channel capacity farther downstream from the dam is the result of reduced peak flows. In intermittent systems such as Willow Creek this does not occur as is shown in Table 2. Because intermittent streams do not have the continuous base flow that perennial streams have they respond differently to an altered flow regime.

Table 2. *Cross-sectional areas of the channel reaches above and below each reservoir.*

	Cross-sectional area (sq. ft.) above detention dam			Cross-sectional area (sq.ft.) below detention dam		
	1	2	3	4	5	6
Sheepshed	5.8	1.3	1.9	1.8	0.6	3.7
Camp	5.0	0.6	2.2	16.9	16.9	9.4
Mudpot	5.4	10.1	12.3	5.3	8.0	7.2
Forest	7.1	7.1	18.8	20.1	8.3	8.3
Collins	42.9	85.4	51.1	32.5	4.5	31.3

The cross-sectional areas below the reservoirs vary and there was no observable correlation between reservoirs that are functioning (detaining flows) and those that are not. There is scouring immediately below the structures at the outlet pipes as one would expect, yet in some cases the channel capacity continues to increase rather than decrease as you move farther from the structure. Examples of this are the cross-sections below Sheepshed and Mudpot reservoirs. Below Sheepshed, cross-sections 4 and 5, immediately below the dam, have a smaller cross-sectional area than cross-section 6, which is farthest from the impoundment. Below Mudpot cross-section 4, which is closest to the structure, has a smaller cross-sectional area than cross-sections 5 and 6.

The channels below Camp and Forest reservoirs are reacting similarly to those mentioned in the studies in Chapter 1, Literature Review. Cross-section 6 below Camp, farthest from the reservoir, has a cross-sectional area that is half that of cross-sections 4 and 5. Below Forest cross-section 4, closest to the dam, has an area that is more than twice the area of cross-sections 5 and 6.

Cross-sections 4 and 6 below Collins reservoir have similar areas, however, cross-section 5, has a much smaller area. I suspect that this is due to the wrong determination of the bankfull elevation and not aggradation of the channel at this site. The measured width for twice bankfull at cross-section 5 is

similar to the measured widths at the bankfull elevations of cross-sections 4 and 6. This leads me to believe that the elevation measured at twice bankfull is actually the bankfull elevation. This is another example of the problems associated with determining bankfull in intermittent stream systems.

Sheepshed Reservoir

Sheepshed is a fourth order basin with a drainage area of approximately 32 square kilometers (12.4 square miles). Other geomorphological characteristics of this sub-basin are listed in Appendix A-6.

In 1990 the RWRP inventoried two polygons and rated the health and function of the channel near Sheepshed Reservoir. In 1996 these polygons were reinventoried. Both the 1990 and 1996 inventories found the areas to be functioning-at-risk (Table 3).

Table 3. Summary of health and function ratings in 1990 and 1996 for the polygons inventoried near Sheepshed Reservoir.

Polygon number	Category	1990		1996	
01	vegetation	83.3 %	healthy	88.0%	healthy
	soils/geology	66.7 %	at risk	66.7%	at risk
	hyro/banks	66.7 %	at risk	66.7%	at risk
	total	75.0 %	at risk	71.0%	at risk
02	vegetation	66.7%	at risk	77.0%	at risk
	soils/geology	66.7%	at risk	66.7%	at risk
	hyro/banks	66.7%	at risk	58.0%	unhealthy
	total	66.7%	at risk	64.0%	at risk

The area is predominantly *Artemisia canal/Agropyron smithii* (silver sagebrush/western wheatgrass) habitat type. The vegetation category for polygon one was determined to be healthy both in 1990 and in 1996. The vegetation score in polygon 2 was at-risk for both inventories; however, there was substantial improvement from 1990 to 1996. The improvement in vegetation is due to improved grazing management. The rest-rotation grazing system for the allotment surrounding Sheepshed Reservoir has only been in use for the past four years. Prior to this grazing in this allotment was season long.

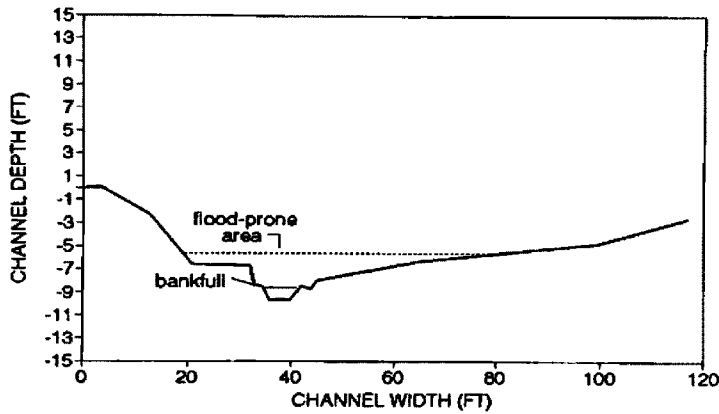
Soils/geology and hydrology/streambanks were given either at-risk or unhealthy ratings for each polygon both in 1990 and 1996. These lower ratings may be the result of early spring grazing by livestock. The cattle are moved into the allotment as early as April, when soil moisture is high and trampling causes the most bank damage.

Aerial photos of the area taken in 1949 and again in 1981 show an increase in herbaceous vegetation, particularly along the stream channel. There is no noticeable change of upland vegetation from 1949 to 1981. No trees, either live or decadent, appear in any of the photos, either above or below the impoundment.

The three reaches surveyed above Sheepshed are classified as Rosgen C6 channel types. Below Sheepshed, cross-sections 4 and 5 are Rosgen F6

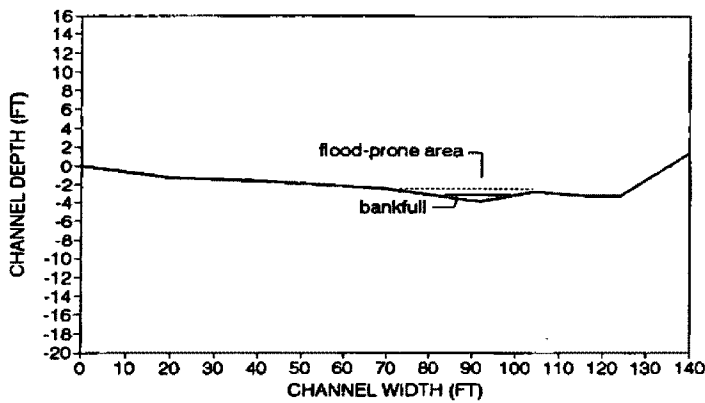
channels and cross-section 6 is a Rosgen C6 channel. Graphs of the cross-sections are shown in figures 8 and 9. The measured values for classifying channel types are listed in Appendix A-1. Sheepshed has a much smaller drainage area than the other basins in the study. Because of there is less runoff into the channel from overland flow, which lessens the erosive impacts from the water moving through the system.

CROSS SECTION #1



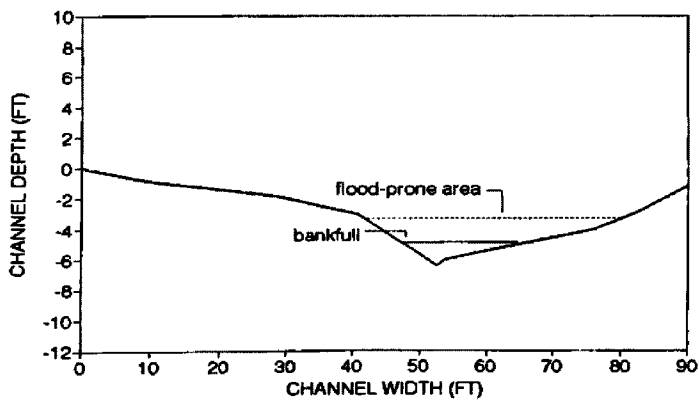
channel type: C6
 entrenchment: 5.3
 width/depth: 14.9
 slope: 0.0009
 sinuosity: 3.0

CROSS SECTION #2



channel type: C6
 entrenchment: 1.5
 width/depth: 32.5
 slope: 0.0009
 sinuosity: 3.0

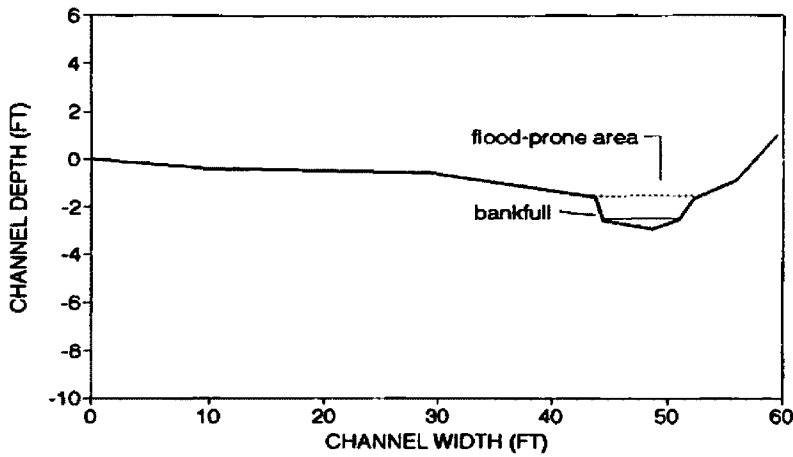
CROSS SECTION #3



channel type: C6
 entrenchment: 5.7
 width/depth: 17.0
 slope: 0.009
 sinuosity: 3.0

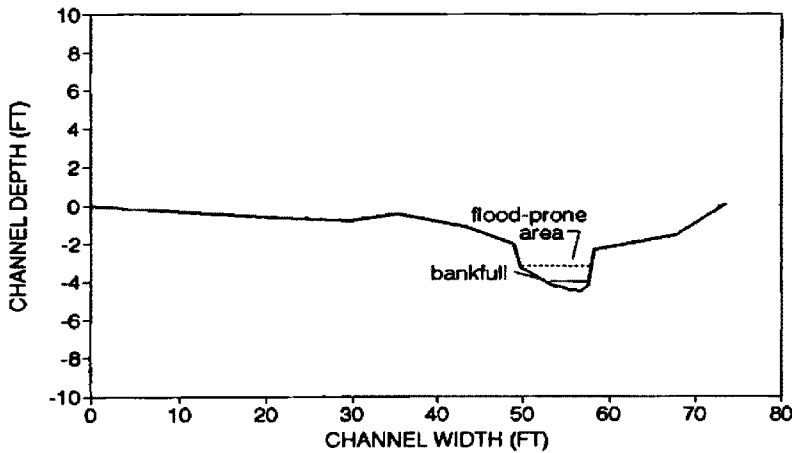
Figure 8. Cross-section graphs above Sheepshed Reservoir.

CROSS SECTION #4



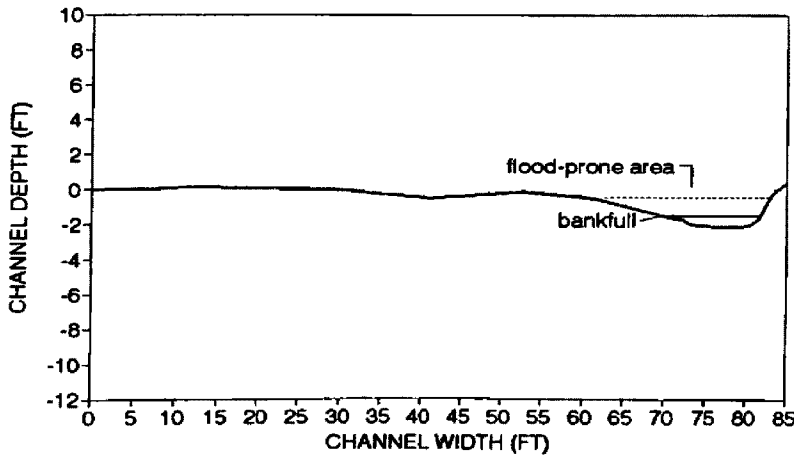
channel type: F6
 entrenchment: 1.3
 width/depth: 28.3
 slope: 0.006
 sinuosity: 2.0

CROSS SECTION #5



channel type: F6
 entrenchment: 1.9
 width/depth: 29.1
 slope: 0.006
 sinuosity: 2.0

CROSS SECTION #6



channel type: C6
 entrenchment: 1.7
 width/depth: 34.1
 slope: 0.006
 sinuosity: 2.0

Figure 9. Cross-section graphs below Sheepshed Reservoir.

Camp Reservoir

Camp is a fourth order basin with a drainage area of approximately 55 square kilometers (21.2 square miles) including the Sheepshed drainage area. Without Sheepshed drainage included, the drainage area would be approximately 23 square kilometers (8.8 square miles). Other geomorphological characteristics for this area are listed in Appendix A-6.

Vegetation inventories and health and function evaluations for 1990 and 1996 (Table 4) show that the channel and riparian area above and below Camp have improved somewhat and are in an upward trend. Dominant habitat types are *Artemisia cana/Agropyron smithii* (silver sagebrush/western wheatgrass) and *Elocharis palustris* (common spikeseed).

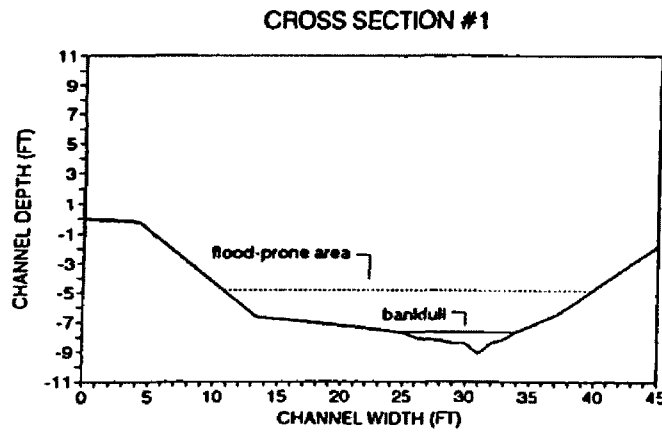
Table 4. Summary of health and function ratings in 1990 and 1996 for the polygons inventoried above and below Camp Reservoir.

Polygon number	Category	1990	1996
05	vegetation	57.1% unhealthy	66.7% at risk
	soils/geology	100% healthy	100.0% healthy
	hydro/banks	50.0% unhealthy	75.0% at risk
	total	61.5% unhealthy	76.7% at risk
06	vegetation	61.9% at risk	75.0% at risk
	soils/geology	66.7% at risk	83.0% healthy
	hydro/banks	50.0% unhealthy	77.0% at risk
	total	59.0% unhealthy	77.0% at risk

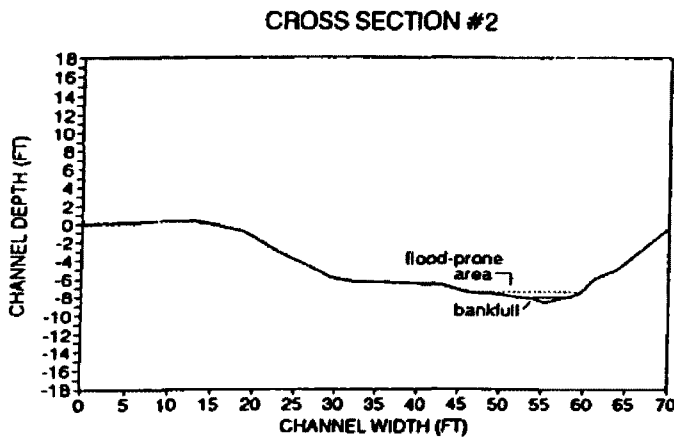
The 1990 inventory rated the polygons as non-functioning or unhealthy. This was due to the vegetation rating and the condition of the channel banks. There was no evidence of tree regeneration and less than five percent of the area was occupied by woody species. Only 75 to 84 percent of the soil surface was covered by plant growth. The 1996 inventories show that the area has improved to functioning at risk. All aspects (vegetation, soils/geology, hydrology/banks) received higher ratings (Appendix B). Polygon 5 is located above Camp Reservoir, once again, the rest-rotation grazing system in this allotment has only been in use for the past four years. There was still no tree regeneration taking place but the combined canopy cover had increased to greater than 85 percent of the soil surface being covered by plant growth. This, along with an increase in the percent of streambanks with a deep binding root mass *Eleocharis palustris* (common spikesedge), helped bring the rating up from non-functioning to functioning at risk.

Aerial photos of the channel above and below Camp show increased vegetation since the time the dam was constructed. The aerial photos studied were for the years 1949, 1953, and 1981. There is no evidence in the photos of trees in the area above Camp and very few in the area below. The later photos show vegetation growing on the newly developing floodplain on the bottom of the old incised channel.

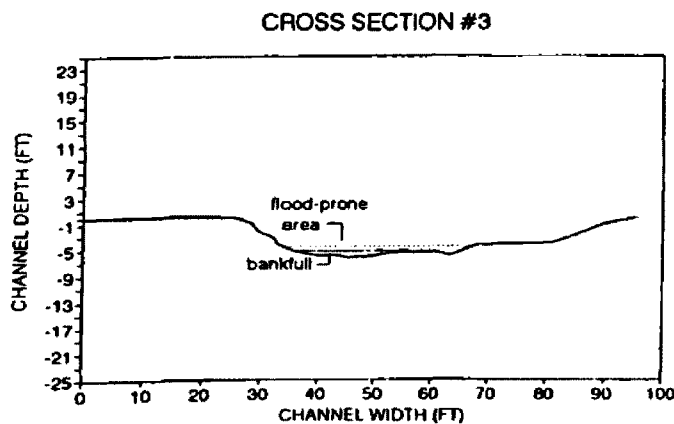
Above Camp Reservoir all reaches surveyed are Rosgen C6 channel types. All cross-sections below Camp are Rosgen G-type channels (figures 10 and 11). The fact that the channel below Camp is virtually a gully is not surprising due to the fact that the dam was built at the site of a major headcut. If the structure had not been put in, the headcut would more than likely have continued to advance up the channel.



channel type: C6
 entrenchment: 3.2
 width/depth: 20.2 f
 slope: 0.003
 sinuosity: 1.4

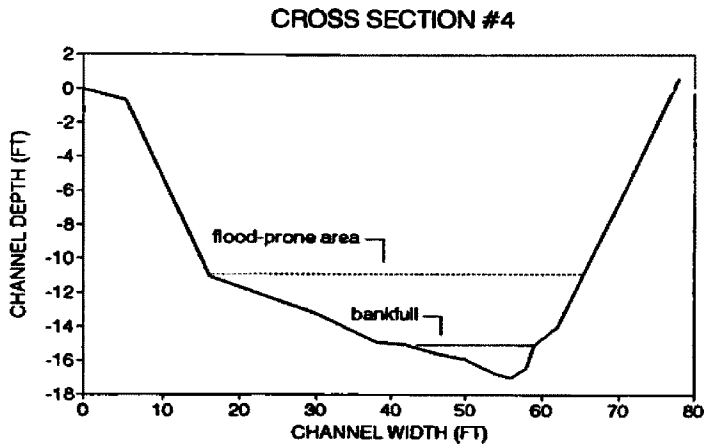


channel type: C6
 entrenchment: 4.6
 width/depth: 15.8 f
 slope: 0.003
 sinuosity: 1.4

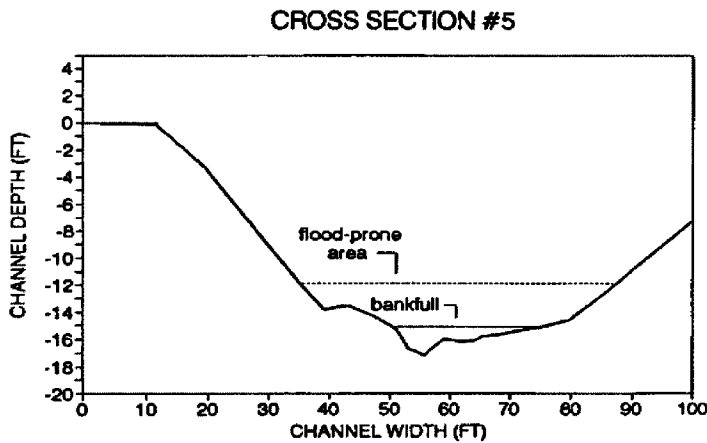


channel type: C6
 entrenchment: 2.6
 width/depth: 57.9
 slope: 0.003
 sinuosity: 1.4

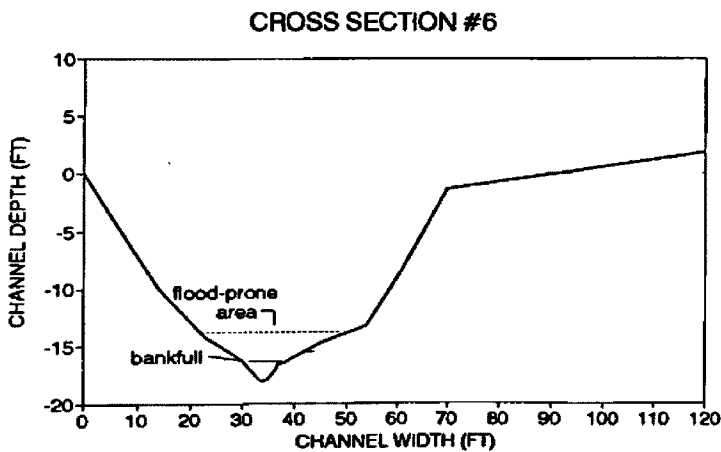
Figure 10. Cross-section graphs above Camp Reservoir.



channel type: G6
 entrenchment: 2.6
 width/depth: 20.2
 slope: 0.003
 sinuosity: 1.6



channel type: G6
 entrenchment: 2.3
 width/depth: 16.9
 slope: 0.003
 sinuosity: 1.6



channel type: G6
 entrenchment: 2.6
 width/depth: 8.7
 slope: 0.003
 sinuosity: 1.6

Figure 11. Cross-section graphs below Camp Reservoir.

Mudpot Reservoir

Mudpot is a fifth order basin, the drainage area between Camp and Mudpot is 81.5 square kilometers (31.5 square miles). The drainage area from the headwaters of Willow Creek to Mudpot is 174.5 square kilometers (67.4 square miles). Other geomorphological characteristics are listed in Appendix A-6.

The 1990 RWRP inventory and health and function evaluation determined the riparian area below Mudpot Reservoir to be non-functioning (unhealthy) (Table 5).

Table 5. *Summary of health and function ratings in 1990 and 1996 for the polygons inventoried below Mudpot Reservoir.*

polygon number	category	1990	1996
07	vegetation	47.6% unhealthy	71.0% at risk
	soils/geology	66.7% at risk	83.0% healthy
	hydro/banks	50.0% unhealthy	66.7% at risk
	total	51.3 unhealthy	72.0% at risk

This low rating once again was due to the vegetation assessment and the hydrology and stream banks. The vegetation evaluation received a low rating due to the lack of regeneration of both trees and shrubs. According to the inventory, less than one percent of the total canopy cover of trees and shrubs

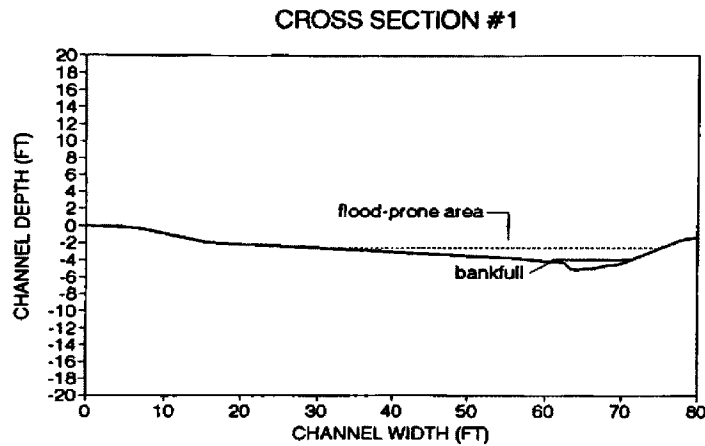
was represented by seedlings and saplings. Fifteen to thirty-four percent of the stream bank was showing active lateral cutting.

The 1996 inventory shows a marked improvement from non-functioning condition to functioning at risk. Regeneration of trees and shrubs and the combined canopy cover has increased which increases the overall vegetation rating (Appendix B). The predominant habitat type is *Artemisia cana/Agropyron smithii* (silver sagebrush/western wheatgrass). Community types include *Populus deltoides/Herbaceous* (Great Plains cottonwood/Herbaceous) and *Salix exigua* (sandbar willow).

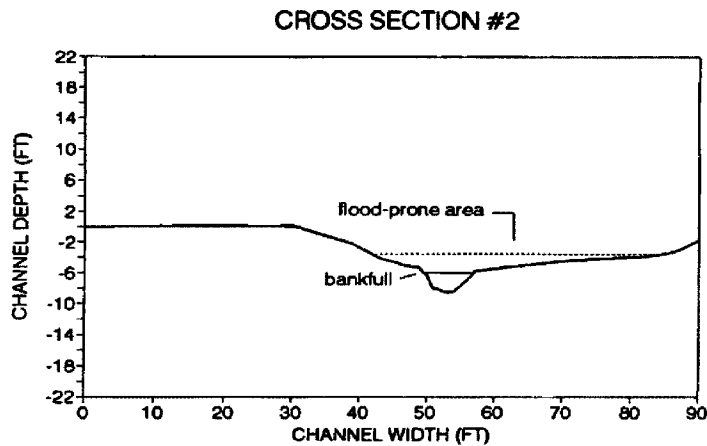
Aerial photos of the area taken in 1949, 1953, and 1981 were compared to determine changes in vegetation from before and after the construction of the dam. In the riparian area above Mudpot Reservoir, there is an apparent increase in the vegetative cover shown in the 1981 photos. In the 1981 photos there also appears to be a new floodplain developing on the bottom of the old channel. This floodplain is not evident in the previous photos.

Although there are a few trees in the riparian area below Mudpot Reservoir, there appears to be no regeneration between the time periods shown in the aerial photos. The channel is incised with no new floodplain development taking place. The aerial photos do not indicate an increase in vegetation over the years between 1949 and 1981.

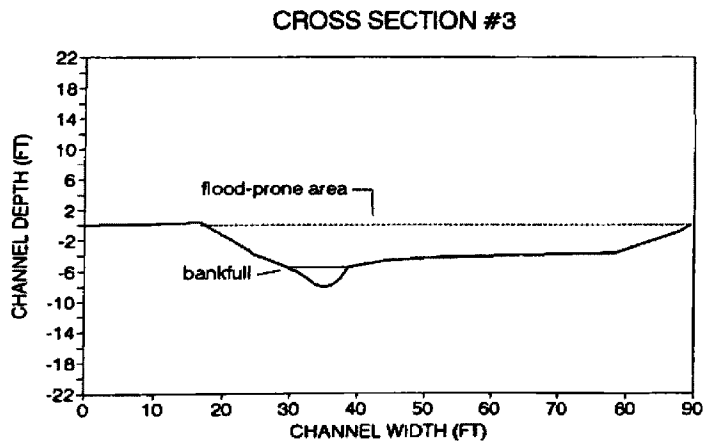
The cross-sections of the channel above Mudpot Reservoir are Rosgen C6 stream types, while the cross-sections below are all Rosgen G6 stream types (figures 12 and 13). Like Camp, Mudpot was also constructed at the site of a major headcut, and therefore the channel below is classified as a G, or a gully. Once again the structure prevented the headcut from advancing up the channel.



channel type: C6
 entrenchment: 5.0
 width/depth: 20.6
 slope: 0.0009
 sinuosity: 1.3



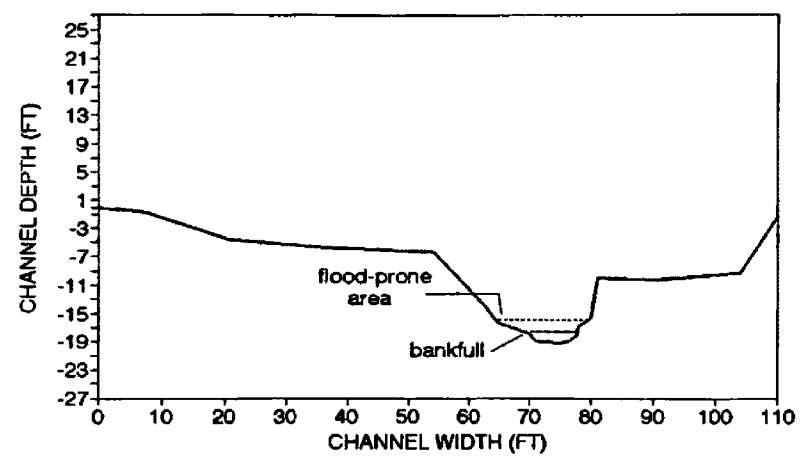
channel type: C6
 entrenchment: 5.9
 width/depth: 5.8
 slope: 0.0009
 sinuosity: 1.3



channel type: C6
 entrenchment: 10.7
 width/depth: 6.3
 slope: 0.0009
 sinuosity: 1.3

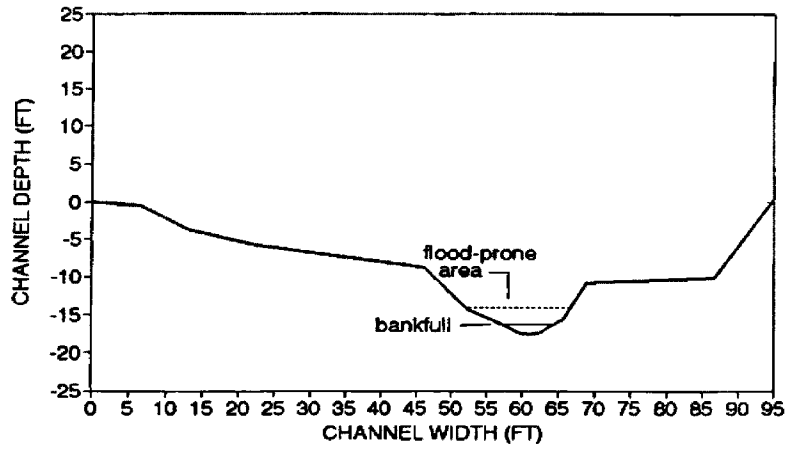
Figure 12. Cross-section graphs above Mudpot Reservoir.

CROSS SECTION #4



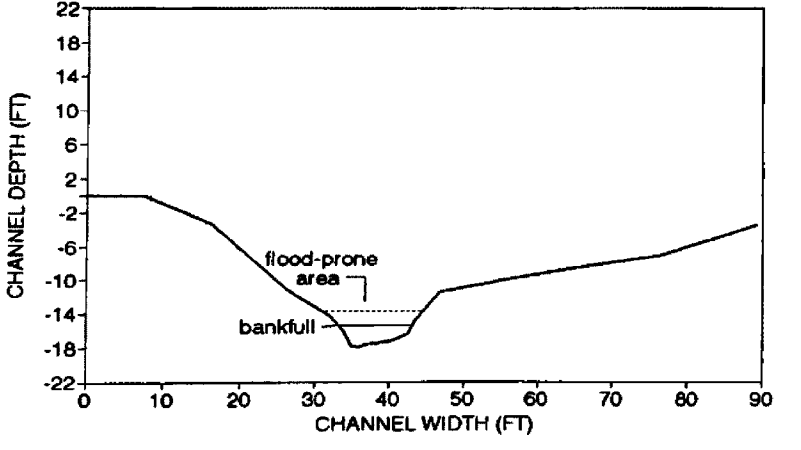
channel type: G6
entrenchment: 2.4
width/depth: 6.8
slope: 0.0004
sinuosity: 1.7

CROSS SECTION #5



channel type: G6
entrenchment: 2.2
width/depth: 7.7
slope: 0.0004
sinuosity: 1.7

CROSS SECTION #6



channel type: G6
entrenchment: 2.0
width/depth: 9.2
slope: 0.0004
sinuosity: 1.7

Figure 13. Cross section graphs below Mudpot Reservoir.

Forest Reservoir

Forest Reservoir is a fifth-order basin; the drainage area is 236 square kilometers (91.2 square miles) for the basin above Forest Reservoir and 27.4 square kilometers (10.6 square miles) for the area between Mudpot and Forest Reservoirs. Other geomorphological characteristics are listed in Appendix A-6.

The 1990 RWRP inventory shows that the riparian area surrounding Forest is in non-functioning (unhealthy) condition (Table 6). There was no

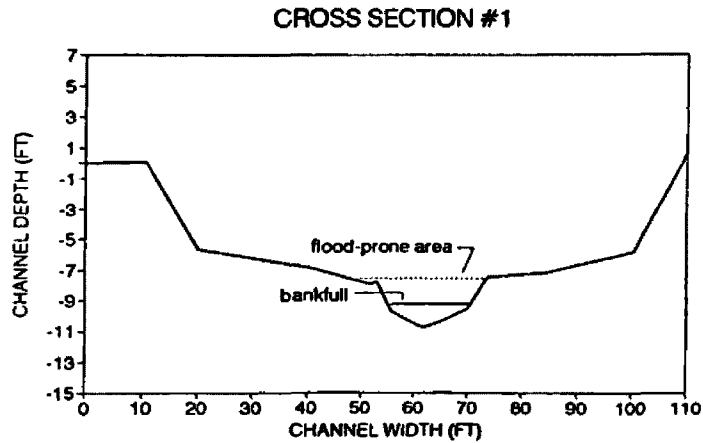
Table 6. *Summary of health and function ratings in 1990 and 1996 for the polygon inventoried near Forest Reservoir.*

Polygon number	Category	1990	1996
08	vegetation	47.6% unhealthy	71.0% at risk
	soils/geology	66.7% at risk	83.0% healthy
	hydro/banks	50.0% unhealthy	66.7% at risk
	total	51.3 unhealthy	72.0% at risk

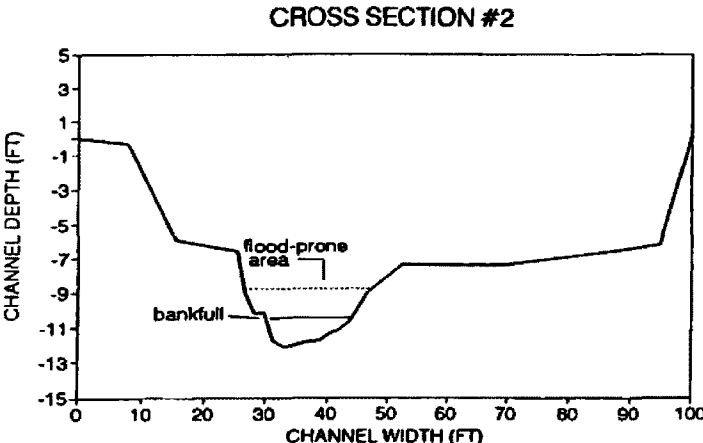
regeneration of trees or shrubs within the polygon, and the combined canopy cover by all plant lifeforms was less than 75 percent. At the time of the inventory 15 to 34 percent of the streambank was showing active lateral cutting. These factors contributed to the low rating. Habitat type was *Artemisia cana/Agropyron smithii* (silver sagebrush/western wheatgrass) and community type was *Populus deltoides* (Great Plains cottonwood)/herbaceous.

As with the Camp and Mudpot riparian areas, there was some improvement in the health and function of the riparian area from 1990 to 1996. There is still no tree regeneration, but there was improvement in shrub regeneration and the total canopy cover of all lifeforms (Appendix B).

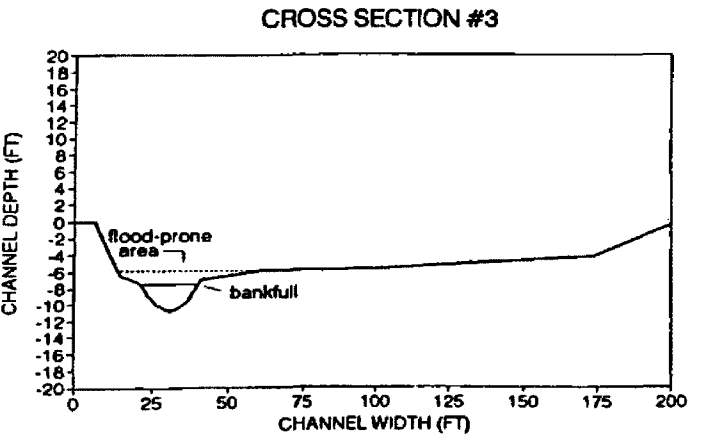
Using Rosgen's classification system, six channel reaches were surveyed. The graphs of these cross-sections are shown in figures 14 and 15. Cross-sections one and two are F6 channel types. Cross-sections three through six are C6 channel types. Unlike Camp, Collins, and Mudpot reservoirs, Forest was not constructed at the site of a major headcut. Therefore there is not the extreme change in channel types from above or below the reservoir.



channel type: F6
entrenchment: 1.8
width/depth: 20.5
slope: 0.0002
sinuosity: 1.3

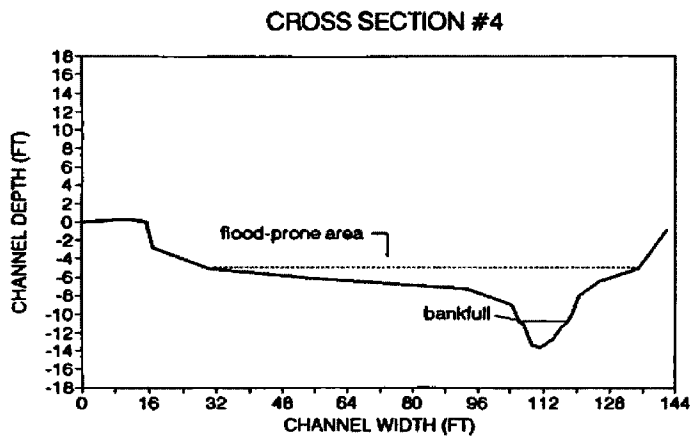


channel type: F6
entrenchment: 1.6
width/depth: 20.0
slope: 0.0002
sinuosity: 1.3

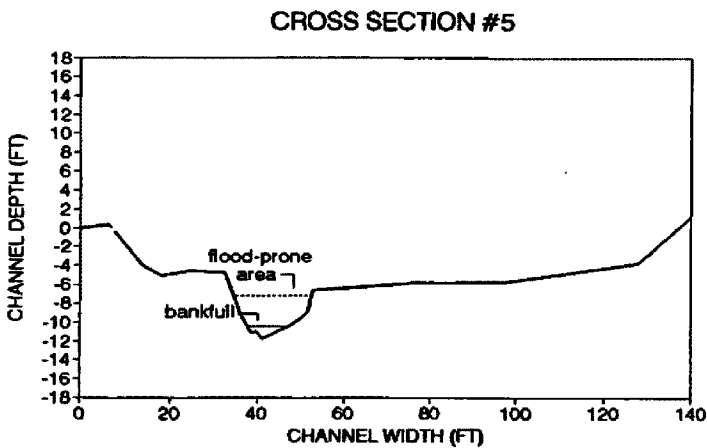


channel type: C6
entrenchment: 5.2
width/depth: 11.4
slope: 0.0002
sinuosity: 1.3

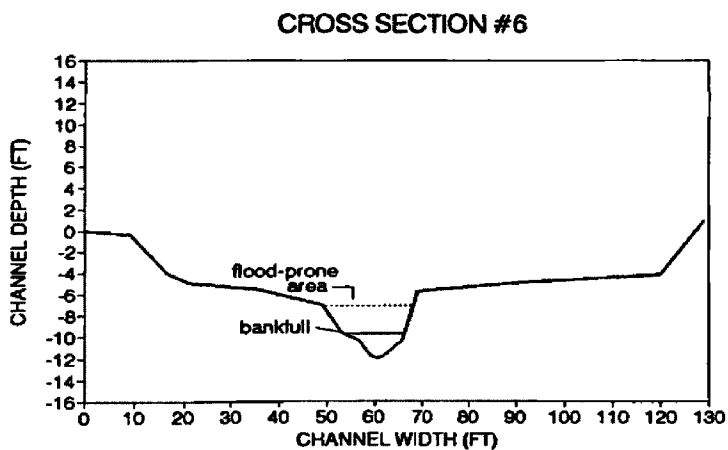
Figure 14. Cross-section graphs above Forest Reservoir.



channel type: C6
 entrenchment: 7.0
 width/depth: 8.9
 slope: 0.0005
 sinuosity: 1.4



channel type: C6
 entrenchment: 2.3
 width/depth: 13.4
 slope: 0.0005
 sinuosity: 1.4



channel type: C6
 entrenchment: 2.1
 width/depth: 10.2
 slope: 0.0005
 sinuosity: 1.4

Figure 15. Cross-section graphs below Forest Reservoir.

Collins Reservoir

Collins is also a fifth order basin and the drainage area between Forest Reservoir and Collins is 52.3 square kilometers (20.2 square miles). The total area, including the drainages of the other four reservoirs, is 324.6 square kilometers (125.4 square miles). Other geomorphological characteristics are listed in Appendix A-6.

In 1990 the overall polygon health rating, for the area inventoried below Collins Reservoir, was found to be functioning at risk (Table 7). In 1996 the overall health of the polygon improved to proper-functioning condition.

Table 7. *Summary of health and function ratings in 1990 and 1996 for the polygon inventoried below Collins Reservoir.*

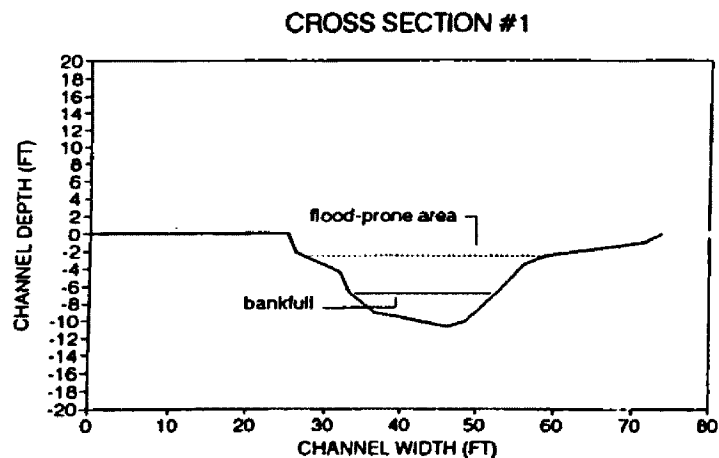
polygon #	category	1990	1996
09	vegetation	61.9% at risk	87.5% healthy
	soils/geology	100.0% healthy	83.0% healthy
	hydro/banks	50.0% unhealthy	78.0% at risk
	total	64.1% at risk	83.0% healthy

Absence of tree regeneration and canopy cover of all plant lifeforms was the cause of the at-risk rating for the vegetation category in 1990. The hydrology/streambanks were considered to be unhealthy because at least 15 to 34 percent of the polygon was showing active lateral cutting.

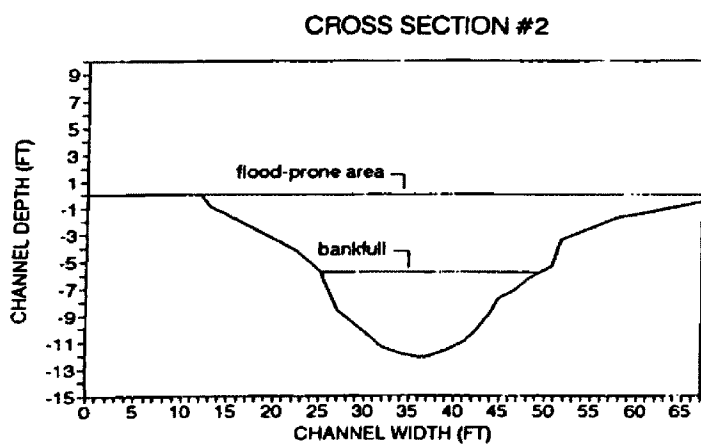
Thirty percent of the polygon consists of *Artemesia cana/Agropyron smithii* (silver sagebrush/western wheatgrass) habitat type, while ten percent is *Elocharis palustris* (common spikesege) habitat type. Community types consist of *Populus deltoides/herbaceous* (Great Plains cottonwood/herbaceous) and *Salix exigua* (sandbar willow).

The health and function of the riparian area has improved in 1996 to proper-functioning condition (Table 5). The pastures above and below Collins reservoir are used only for a short duration in the fall, this more than likely accounts for the considerable improvement in vegetation from 1990 to 1996. Only the hydrology/banks portion of the health ratings are in less-than-proper-functioning condition (Appendix B-5 and C-5).

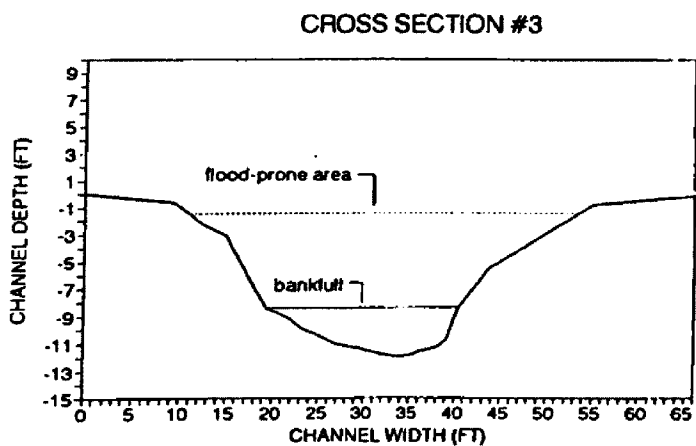
Graphs of the cross-sectional views are shown in figures 16 and 17. Cross-sections one and two above Collins are classified as C6 channel types, while cross-sections three through six are G-type channels. Collins Dam, like Camp and Mudpot was constructed at the site of a major headcut. Because of this the channels below were deeply incised gullies. These channels are still classified as gullies; however, there is obvious improvement taking place. A new floodplain is developing within the old incised channel and vegetation is being established. The C-type channels above indicate, once again, that the structures were successful in stopping the advancement of the headcut.



channel type: C6
 entrenchment: 1.9
 width/depth: 6.9
 slope: 0.001
 sinuosity: 1.2



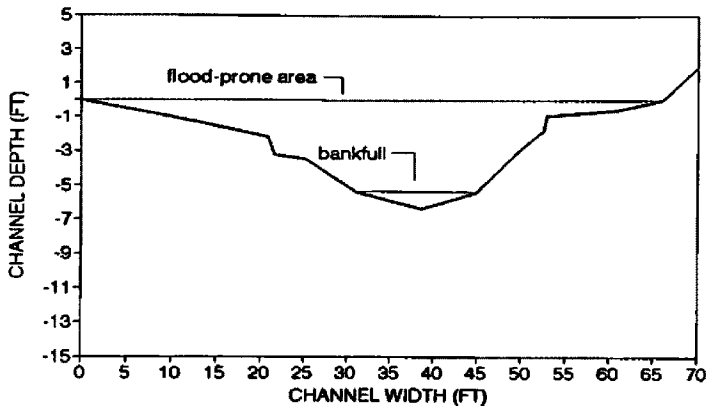
channel type: C6
 entrenchment: 3.0
 width/depth: 6.0
 slope: 0.001
 sinuosity: 1.2



channel type: G6
 entrenchment: 2.1
 width/depth: 8.5
 slope: 0.001
 sinuosity: 1.2

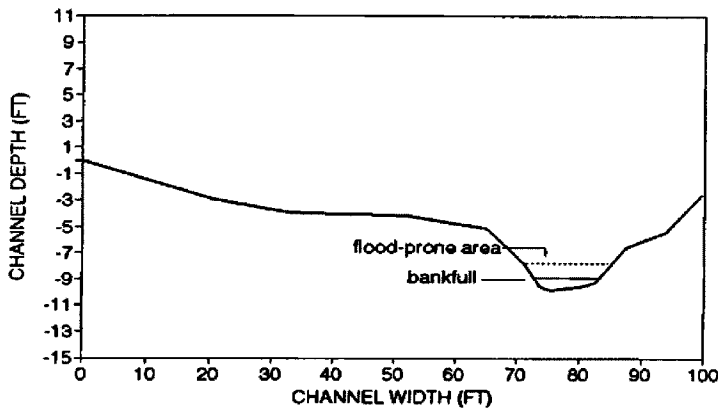
Figure 16. Cross-section graphs above Collins Reservoir.

CROSS SECTION #4



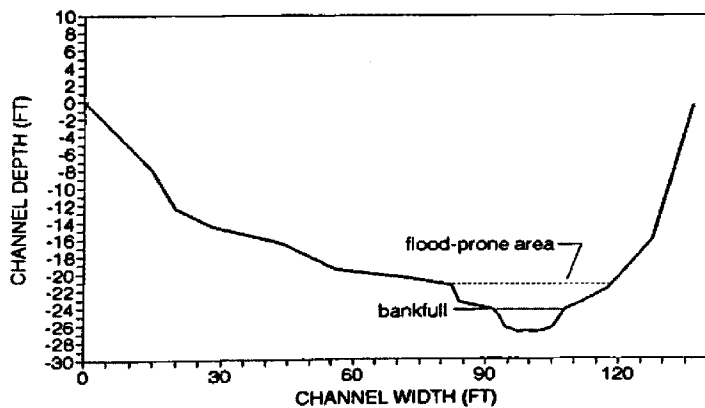
channel type: G6
 entrenchment: 3.8
 width/depth: 10.1
 slope: 0.0007
 sinuosity: 2.5

CROSS SECTION #5



channel type: G6
 entrenchment: 1.2
 width/depth: 25.0
 slope: 0.0007
 sinuosity: 2.5

CROSS SECTION #6



channel type: G6
 entrenchment: 2.1
 width/depth: 8.4
 slope: 0.0007
 sinuosity: 2.5

Figure 17. Cross-section graphs below Collins Reservoir.

Upland Condition

Upland vegetation was first evaluated in 1960, when Branson and Miller (1981) established vegetation plots in the Willow Creek Basin. These plots were monitored in 1960, 1977, and again in 1985 when Miller (1987) did a follow-up study of the vegetation. The range staff at the BLM, Valley Resource Area (VRA) has also inventoried the upland vegetation within the basin since the implementation of grazing systems in 1976.

Branson and Miller found that the reduced grazing intensities and the implementation of a rest-rotation grazing system, along with higher average annual precipitation, resulted in the improvement of rangeland vegetation. According to Miller (1987) "there has been a marked improvement in upland vegetation since 1960. In 1977, after ten years of greater-than- average annual precipitation, upland vegetation (grasses) has increased by an average of 17 percent. Shrubs have also increased but not quite as dramatically. After five years of less-than-average annual precipitation, the 1985-86 study showed that the amount of vegetation was less than in 1977; however, it was still more abundant than it was in 1960, before the implementation of grazing systems" (Table 8).

Records obtained from the Valley Resource Area for 1996 show that 73 percent of the acres inventoried are in an upward trend, 27 percent are in a static

trend and none of the acres inventoried were in a downward trend. Upland conditions are largely in late seral and PNC (potential natural community) status.

Table 8. *Summary of live plant-cover changes over time (Miller 1987).*

Vegetation type	Shrubs			Grasses		
	1960	1977	1985	1960	1977	1985
Nuttall saltbush (top of hill)	1.8	11.8	13.7	0.1	31.0	3.9
Big sagebrush (below hilltop)	17.4	31.7	44.0	2.5	33.1	18.8
Annual forb-Western wheatgrass type	0.3	4.5	-----	0.2	39.3	8.0
Buckwheat type	19.4	19.8	32.0	0.2	32.5	9.0
Mixed-shrub type	6.3	8.7	27.0	2.8	39.6	7.0
Big sagebrush type (base of hill)	15.5	4.7	42.9	1.0	27.9	22.0
Nuttall saltbush type (base of hill)	15.6	22.0	17.3	0.5	33.3	10.0
Blue grama-Big sagebrush (On glacial till)	7.0	17.7	24.7	17.4	60.7	46.0
Big sagebrush strip	33.0	46.8	57.4	10.1	36.3	13.8
Greasewood strip	20.6	34.0	35.4	6.5	44.3	11.1
Western-wheatgrass meadow	-----	-----	-----	34.6	140.0	74.0
Greasewood type (on trenched flood plain)	22.6	20.7	26.2	22.4	85.0	70.5
Silver sagebrush type (point bars and oxbows)	18.4	69.5	45.2	15.9	51.9	64.0
	—	—	—	—	—	—
AVERAGES	14.8	27.3	30.5	8.8	50.4	24.4

CHAPTER 5

SUMMARY/CONCLUSIONS

When researching the Willow Creek Basin I found a definite lack of data concerning channel morphology. The only cross-sectional data available concerning channel morphology was from the gaging station, located approximately 64 stream kilometers (forty stream miles) from Collins Reservoir, the lower most reservoir on Willow Creek. I found no monumented cross-sections of the stream channel before or after the construction of the dams. The logical approach to determine changes in the channel and impacts of the flood control structures would be to compare cross sections of the channel from identical points over a period of years. Unfortunately, no such data exists. In addition to the absence of channel condition assessment before the structures were in place, virtually all stream reaches in the basin or similar basins in the area have been altered by human use. There are over 200 water impoundments in the Willow Creek Basin alone. For this reason there are no reference sites to compare what has happened to the reaches affected by the dams versus a reach unaltered by human use.

There is no way to quantitatively measure the channel changes over the years, since the construction of the dams. Yet, qualitative determinations can be made, by classifying the stream channel and determining its condition with regard to morphology and vegetation. Quantitative changes can be determined in future years with continued monitoring of the area.

Based on aerial photos and data acquired from classification surveys the channel in most areas of the study appears to have progressed to a more stable type than at the time the structures were put in. The headcuts that were advancing so rapidly in the early 1950s at the site of Collins (figure 18) and Camp reservoirs have been stopped by the dams as can be seen by the aerial photos.

Three types of channels are found above and below Sheepshed, Camp, Mudpot, Forest, and Collins Reservoirs (Table 9). Of the 15 cross-

Table 9. *Rosgen channel types for each cross-section surveyed above and below each reservoir.*

	1	2	3	4	5	6
Sheepshed	C6	C6	C6	F6	F6	C6
Camp	C6	C6	C6	G6	G6	G6
Mudpot	C6	C6	C6	G6	G6	G6
Forest	F6	F6	C6	C6	C6	C6
Collins	C6	C6	G6	G6	G6	G6

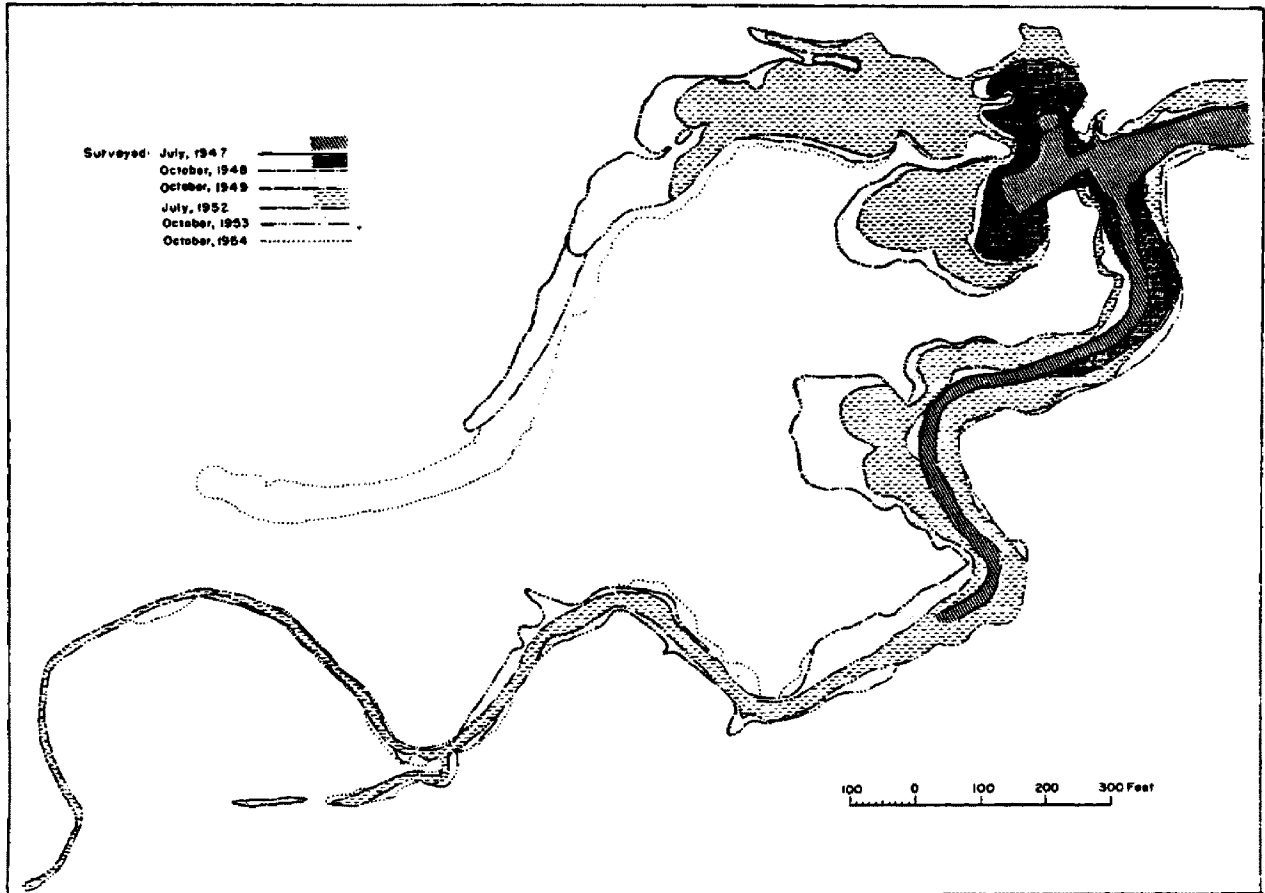


Figure 18. Advancement of the headcut at Collins Reservoir (1947-1954)
(Miller 1987).

sections surveyed above the reservoirs, 12 are C6 channel types, two are F6 channel types and one is a G6 channel type. Below the reservoirs only four of the 15 cross-sections are C6 channel types while nine of the 15 are G6 types. There are two F6 channel types.

Below Camp, Mudpot, and Collins Reservoirs, all of which were built at the site of major headcuts, the channel reaches surveyed were all G6 channels. Above these reservoirs with the exception of cross-section 3 above Collins, the channel reaches were all C6 channel types. This is further evidence that the structures were successful in stopping the advancement of headcuts in the basin.

The overall condition of the Willow Creek Basin has improved since the construction of the dams. Upland vegetation has improved as is evident by the studies conducted by Branson and Miller (1981), Miller (1987) and the 1996 inventories conducted by the BLM, Valley Resource Area . Improvement of upland vegetation helps to decrease the amount of runoff flowing directly into the channel, reduces peak flows, and in turn, helps to decrease channel erosion.

Riparian vegetation has also improved as is shown by comparison of the 1990 and 1996 riparian inventories. The improved vegetation over this six year period can be attributed to improve grazing management within the basin. Trees, shrubs and other plants having a deep binding root mass (perennial

species with a rhizomatous root system), have increased in the riparian areas within the study. Vegetation with deep binding root mass provides the greatest amount of protection to the streambanks. The protection provided by these plants reduces erosion of the channel banks during peak flows and also reduces the damage caused from animal trampling.

Collected channel morphology data indicates that the channels themselves appear to be moving toward a more stable state. There are areas where the stream is still a G channel, but field data indicates that improvement is taking place. Aerial photos, taken from before and several years after the dams were constructed, show headcuts that were previously advancing have been stopped and in the G channels, new floodplains are being developed and vegetated. These channels appear to be evolving towards F channel types while the F channels are moving towards C channel types. This pattern follows the evolution of stream types discussed in Rosgen's book *Applied River Morphology* (1996). Erosion and sedimentation of the area has also decreased as is evident by the data collected, between 1955 and 1986, from the Willow Creek gaging station.

According to Rosgen (1996), "evolutionary sequence takes place in the presence of 'good' riparian conditions, where vegetation provides the necessary resistance to flow forces, illustrating the stream's ability to reach a condition or

state described as natural stability." Livestock have a definite impact (Marlow and others 1987; Clary and others 1996) on vegetation and vegetation has an impact on channel stability (USDI 1989; Hansen and others 1995; Rosgen 1996). Included in the RWRP inventory is an assessment of the livestock utilization of the riparian vegetation, a necessary component in the overall assessment of the basin. In all of the polygons, with the exception of those near Sheepshed, the amount of exposed soil surfaces, due to grazing, has decreased.

Changing the grazing management within the basin has allowed for improved upland and riparian vegetation conditions. This is evident from the upland inventories taken in subsequent years, from 1960 to 1996, and from the riparian inventories conducted in 1990 and again in 1996. Dan Muller (1996), previous Valley Resource Area hydrologist, visually noted a marked improvement in the overall vegetative condition of upland and riparian areas in the basin as compared to conditions in 1980.

CHAPTER 6

RECOMMENDATIONS

Willow Creek has shown continuous improvement in channel stability and in vegetation, both amount and type, since the construction of the dams. This is due to a reduction in peak flows as a result of the structures. Also, improved grazing management within the basin has allowed for increased ground cover in both upland and riparian areas. However, the established vegetation may not be enough to protect the banks from increases in peak flows, as the structure fail. For this reason the following recommendations are suggested to assure continued improvement of Willow Creek.

The permanent cross-sections established in this study should be resurveyed in subsequent years to determine any changes that occur within the channel above and below the impoundments. Comparing the cross-sections below structures that are functioning to those that are not may also help to determine the effects the structures themselves have upon the channel. Where feasible, stream channel restoration should be considered to prevent erosion that will result from channel adjustment. The difference in slope above

and below the dams would cause the headcuts to begin advancing up the channel as the dams breach. One method of restoration could be the use of check dams within the channel. This may be one possible solution to maintaining the benefits that have resulted from the construction of the dams. Heede (1960; 1970; 1976; 1977) has done extensive work in the restoration of gully systems, using check dams. In a study conducted on the upper Alkali Creek watershed in Colorado, Heede (1977) found that the check dams resulted in substantial decrease in gully depth and bank toe stabilization, which led to gentler gully side slopes. This, in turn, allowed for vegetation to establish on the banks.

Another option is to construct a Rosgen C-type channel through the old sediment pool. This would involve lengthening the channel by developing meanders to adjust for the difference in slope. However, this method would be costly and may not be economically feasible.

A third alternative is to construct a Rosgen B-type channel through the existing dam. This may not be practical because the materials needed to withstand the increased velocities of a B-type channel are not readily available in the immediate area.

The improved grazing management within the basin will continue to provide protection to both upland and riparian vegetation, which will in turn

provide protection for the stream channels. The improvement of riparian vegetation within the study area will help to slow the advancement of headcuts and protect the channel banks. This, however, is not adequate to keep the headcuts from advancing or the channel banks from eroding without some restoration of the channel itself. This was evident at Collins and Camp Reservoirs, both of which had failed at the time of this study. Headcuts began to advance up through the accumulated sediment behind the dams. If these headcuts continue to advance up the channel the riparian zone would be dewatered, which could eliminate most of the riparian vegetation that has established since the time the dams were constructed. Allowing the structures to fail without attempting to adjust for the difference in slope above and below the impoundments could be detrimental to the progress that has been made within the basin.

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APPENDIX A

A1-A5. Delineative criteria for cross-sections above and below each reservoir.

A6. Geomorphological characteristics of each sub-basin.

A-1. Delineative criteria for cross-sections above and below Sheepshed.

Sheepshed T25N R35E Sections 25, 26, 35 & 36						
	Above Sheepshed			Below Sheepshed		
cross section	1	2	3	4	5	6
distance from dam (miles)	1.0	0.9	0.6	0.3	0.5	0.7
bankfull width (ft.)	10.4	6.5	5.6	6.5	4.1	10.6
area (sq. ft.)	5.8	1.3	1.9	1.8	0.6	3.7
mean depth (ft.)	0.7	0.2	0.3	0.2	0.1	0.3
width/depth ratio	14.9	32.5	17.0	28.3	29.1	34.1
maximum depth (ft.)	1.3	0.4	0.8	0.4	0.2	0.45
2 x max. depth (ft.)	2.6	0.8	1.6	0.8	0.4	0.9
floodprone width (ft.)	55.7	27.8	31.7	8.3	7.9	17.7
entrenchment ratio (ft/ft)	5.3	1.5	5.7	1.3	1.9	1.7
water surface slope (ft/ft)	0.009	0.009	0.009	0.006	0.006	0.006
channel material	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay
sinuosity	3.0	3.0	3.0	2.0	2.0	2.0
channel type	C6	C6	C6	F6	F6	C6

A-2. Delineative criteria for cross-sections above and below Camp.

Camp T25N R36E Sections 33 & 34						
	Above Camp			Below Camp		
cross section	1	2	3	4	5	6
distance from dam (miles)	0.6	0.5	0.4	0.3	0.5	0.9
bankfull width (ft.)	9.3	3.2	11.0	18.8	24.3	9.0
area (sq. ft.)	5.0	0.6	2.2	16.9	16.9	9.4
mean depth (ft.)	0.5	0.2	0.2	0.9	1.4	1.0
width/depth ratio	20.2	15.8	57.9	20.2	16.9	8.7
maximum depth (ft.)	1.4	0.4	0.4	2.0	2.7	1.8
2 x max. depth (ft.)	2.8	0.8	0.8	4.0	5.4	3.6
floodprone width (ft.)	30.0	14.5	28.3	49.0	56.2	23.0
entrenchment ratio (ft/ft)	3.2	4.6	2.6	2.6	2.3	2.6
water surface slope (ft/ft)	0.003	0.003	0.003	0.003	0.003	0.003
channel materials	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay
sinuosity	1.4	1.4	1.4	1.6	1.6	1.6
channel type	C6	C6	C6	G6	G6	G6

A-3. Delineative criteria for cross-sections above and below Mudpot.

Mudpot T25N R37E Section 31 & T24N R37E Section 6						
	Above Mudpot			Below Mudpot		
cross section	1	2	3	4	5	6
distance from dam (miles)	1.2	1.1	0.5	0.2	0.4	0.6
bankfull width (ft)	10.3	7.6	8.7	6.1	7.7	8.3
area (sq ft)	5.4	10.1	12.3	5.3	8.0	7.2
mean depth (ft)	0.5	1.3	1.4	0.9	1.0	0.9
width/depth ratio	20.6	5.8	6.3	6.8	7.7	9.2
maximum depth (ft)	1.0	2.5	2.5	1.2	1.4	1.4
2 x max. depth (ft)	2.0	5.0	5.0	2.4	2.8	2.8
floodprone width (ft)	52.0	44.9	92.8	14.4	16.8	16.8
entrenchment ratio (ft/ft)	5.0	5.9	10.7	2.4	2.2	2.0
water surface slope (ft/ft)	0.0009	0.0009	0.0009	0.0004	0.0004	0.0004
channel materials	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay
sinuosity	1.3	1.3	1.3	1.7	1.7	1.7
channel type	C6	C6	C6	G6	G6	G6

A-4. Delineative criteria for cross-sections above and below Forest.

Forest T25N R37E Sections 27 & 28						
	Above Forrest			Below Forrest		
cross section	*1	*2	3	4	5	6
distance from dam (miles)	1.7	1.4	1.1	0.3	0.4	0.6
bankfull width (ft)	12.3	12.0	14.8	13.4	10.7	9.2
area (sq ft)	7.1	7.1	18.8	20.1	8.3	8.3
mean depth (ft)	0.6	0.6	1.3	1.5	0.8	0.9
width/depth ratio	20.5	20.0	11.4	8.9	13.4	10.2
maximum depth (ft)	0.9	1.0	2.0	2.9	1.5	1.7
2 x max. depth (ft)	1.8	2.0	4.0	5.8	3.0	3.4
floodprone width (ft)	22.3	19.5	77.0	94.3	25.3	19.4
entrenchment ratio (ft/ft)	1.8	1.6	5.2	7.0	2.3	2.1
water surface slope (ft/ft)	0.0002	0.0002	0.0002	0.0005	0.0005	0.0005
channel materials	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay
sinuosity	1.3	1.3	1.3	1.4	1.4	1.4
channel type	F6	F6	C6	C6	C6	C6
*entrenchment doesn't fall within the classification range						

A-5. Delineative criteria for cross-sections above and below Collins.

Collins T25N R37,38E sections 25, 26 & 19						
	Above Collins			Below Collins		
cross section	1	2	3	4	5	6
bankfull width (ft)	17.3	22.5	20.8	18.2	10.0	16.2
area (sq ft)	42.9	85.4	51.1	32.5	4.5	31.3
mean depth (ft)	2.5	3.7	2.4	1.8	0.4	1.9
width/depth ratio	6.9	5.9	8.5	10.1	25.0	8.4
maximum depth (ft)	4.2	5.7	3.5	2.5	0.7	2.6
2 x max depth (ft)	8.4	11.5	7.0	5.0	1.4	5.3
floodprone width (ft)	33.0	67.3	43.5	69.7	12.4	34.8
entrenchment ratio (ft/ft)	1.9	2.9	2.0	3.8	1.2	2.1
water surface slope (ft/ft)	0.001	0.001	0.001	0.0007	0.0007	0.0007
channel material	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay	silt/ clay
sinuosity	1.2	1.2	1.2	2.5	2.5	2.5
channel type	C6	C6	G6	G6	G6	G6

**A-6. Geomorphological characteristics of each sub-basin within the study.
Determined using a 1:24,000 topographical map.**

Geomorphological characteristics of each sub-basin					
	Sheepshed	Camp	Mudpot	Forrest	Collins
Basin order	3rd	4th	5th	5th	5th
stream #	45	45	169	84	152
Avg. stream length (mi)	0.79	0.88	0.91	1.04	0.88
basin area (sq. mi.)	12.4 12.4*	8.8 21.2*	31.5 67.4*	10.6 91.2*	20.2 125.4*
drainage density	2.9	4.5	4.9	8.3	6.4
relief ratio	0.02	0.02	0.01	0.01	0.02
*Includes the area from the basins above					

APPENDIX B

Completed 1990 and 1996 RWRP proper functioning condition (health) forms for each polygon inventoried

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record:9000002

Click on the colored text to view the Pfankuch form for this record:9000002

ADMINISTRATIVE DATA

Record ID: 9000002

Date field data collected: 06/28/90 Year: 1990

State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	01

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form? Without Pfankuch

POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	0	0
2. Woody decadent and dead amounts (#31 & #35)	3	3
3. Utilization of trees and shrubs (#34 & #35)	3	1
4. Shrub regeneration (#35)	3	3
5. Total canopy of woody species (#40)	3	1
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	0	0
Vegetation Subtotals	18	15
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	0	0
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	4
Soils/Geology Subtotals	6	4
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	0	0
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	0	0
15. Phankuch rating (#24)	0	0
Hydrology/Streambank Subtotals	12	8
Overall Polygon Health Rating	36	27

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category
Vegetation:	15 / 18	x 100 =	83.3%	Proper Functioning Condition (Healthy)
Soils/Geology:	4 / 6	x 100 =	66.7%	Functional At Risk
Hydro/Bank:	8 / 12	x 100 =	66.7%	Functional At Risk
Total:	27 / 36	x 100 =	75.0%	Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record: **9000002**

Click on the colored text to view the Pfankuch form for this record: **9000002**

ADMINISTRATIVE DATA

Record ID: **9000002**

Date field data collected: 6/25/96	Year: 96
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	01

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form?	Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)		
2. Woody decadent and dead amounts (#31 & #35)		
3. Utilization of trees and shrubs (#34 & #35)		
4. Shrub regeneration (#35)		
5. Total canopy of woody species (#40)		
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	3	3
Vegetation Subtotals	9	8
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	6	6
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	2
Soils/Geology Subtotals	12	8
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	6	0
13. Percent of streambanks with deep, binding root mass (#53)	6	6
14. Stream channel incisement (#61)	6	6
15. Phankuch rating (#24)		
Hydrology/Streambank Subtotals	24	16
Overall Polygon Health Rating	45	32

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category
Vegetation:	8	/	24 x 100 =	88.0% Proper Functioning Condition (Healthy)
Soils/Geology:	8	/	12 x 100 =	66.0% Functional At Risk
Hydro/Bank:	16	/	18 x 100 =	66.0% Functional At Risk
Total:	32	/	54 x 100 =	71.0% Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record:9000005

Click on the colored text to view the Pfankuch form for this record:9000005

ADMINISTRATIVE DATA

Record ID: 9000005

Date field data collected: 06/28/90 | Year: 1990

State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	02

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	26	SW	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2596	Intermittent Stream	1.82

Is PFC (health) evaluated with or without the Pfankuch form? Without Pfankuch

POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	0	0
2. Woody decadent and dead amounts (#31 & #35)	3	3
3. Utilization of trees and shrubs (#34 & #35)	3	1
4. Shrub regeneration (#35)	3	0
5. Total canopy of woody species (#40)	3	1
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	0	0
Vegetation Subtotals	18	12
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	0	0
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	4
Soils/Geology Subtotals	6	4
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	0	0
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	0	0
15. Phankuch rating (#24)	0	0
Hydrology/Streambank Subtotals	12	8
Overall Polygon Health Rating	36	24

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	Status Unknown

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent	Descriptive Category
Vegetation: 12 / 18 x 100 = 66.7%	Functional At Risk
Soils/Geology: 4 / 6 x 100 = 66.7%	Functional At Risk
Hydro/Bank: 8 / 12 x 100 = 66.7%	Functional At Risk
Total: 24 / 36 x 100 = 66.7%	Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record: **9000005**

Click on the colored text to view the Pfankuch form for this record: **9000005**

ADMINISTRATIVE DATA

Record ID: **9000005**

Date field data collected: 6/25/96	Year: 96
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	02

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form?	Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)		
2. Woody decadent and dead amounts (#31 & #35)		
3. Utilization of trees and shrubs (#34 & #35)		
4. Shrub regeneration (#35)		
5. Total canopy of woody species (#40)		
6. Combined canopy cover of four lifeforms (#41)	3	1
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	3	3
Vegetation Subtotals	9	7
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	6	6
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	2
Soils/Geology Subtotals	12	8
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	6	0
13. Percent of streambanks with deep, binding root mass (#53)	6	6
14. Stream channel incisement (#61)	6	4
15. Phankuch rating (#24)		
Hydrology/Streambank Subtotals	24	14
Overall Polygon Health Rating	45	29

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category	
Vegetation:	7	/	9 x 100 =	77.0%	Functional At Risk
Soils/Geology:	8	/	12 x 100 =	66.7%	Functional At Risk
Hydro/Bank:	14	/	24 x 100 =	58.0%	Functional At Risk
Total:	29	/	45 x 100 =	64.0%	Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record:9000012

Click on the colored text to view the Pfankuch form for this record:9000012

ADMINISTRATIVE DATA

Record ID: 9000012

Date field data collected: 06/28/90 Year: 1990

State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	05

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	36E	33	SW	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Murray Hill, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2426	Intermittent Stream	1.5

Is PFC (health) evaluated with or without the Pfankuch form? Without Pfankuch

POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	2
3. Utilization of trees and shrubs (#34 & #35)	3	0
4. Shrub regeneration (#35)	3	2
5. Total canopy of woody species (#40)	3	0
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	0	0
Vegetation Subtotals	21	12
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	0	0
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	6
Soils/Geology Subtotals	6	6
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	2
12. Percent of bank vegetation altered by human-causes (#52)	0	0
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	0	0
15. Phankuch rating (#24)	0	0
Hydrology/Streambank Subtotals	12	6
Overall Polygon Health Rating	39	24

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	Status Unknown

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category	
Vegetation:	12 /	21	x 100 =	57.1%	Nonfunctional (Unhealthy)
Soils/Geology:	6 /	6	x 100 =	100.0%	Proper Functioning Condition (Healthy)
Hydro/Bank:	6 /	12	x 100 =	50.0%	Nonfunctional (Unhealthy)
Total:	24 /	39	x 100 =	61.5%	Nonfunctional (Unhealthy)Y

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record: **9000012**

Click on the colored text to view the Pfankuch form for this record: **9000012**

ADMINISTRATIVE DATA

Record ID: **9000012**

Date field data collected: 6/25/96	Year: 96
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	05

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form?	Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	2
3. Utilization of trees and shrubs (#34 & #35)	3	3
4. Shrub regeneration (#35)	3	2
5. Total canopy of woody species (#40)	3	1
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	3	3
Vegetation Subtotals	24	16
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	6	6
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	6
Soils/Geology Subtotals	12	12
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	6	6
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	6	4
15. Phankuch rating (#24)		
Hydrology/Streambank Subtotals	24	18
Overall Polygon Health Rating	60	46

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent	Descriptive Category
Vegetation: 16 / 24 x 100 = 66.7%	Functional At Risk
Soils/Geology: 12 / 12 x 100 = 100%	Proper Functioning Condition (Healthy)
Hydro/Bank: 18 / 24 x 100 = 75.0%	Functional At Risk
Total: 46 / 60 x 100 = 76.7%	Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record:9000015

Click on the colored text to view the Pfankuch form for this record:9000015

ADMINISTRATIVE DATA

Record ID: 9000015

Date field data collected: 06/28/90 Year: 1990

State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	06

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	36E	33	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Murray Hill, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2419	Intermittent Stream	6.06

Is PFC (health) evaluated with or without the Pfankuch form? Without Pfankuch

POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	3
3. Utilization of trees and shrubs (#34 & #35)	3	1
4. Shrub regeneration (#35)	3	3
5. Total canopy of woody species (#40)	3	1
6. Combined canopy cover of four lifeforms (#41)	3	0
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	0	0
Vegetation Subtotals	21	13
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	0	0
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	4
Soils/Geology Subtotals	6	4
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	2
12. Percent of bank vegetation altered by human-causes (#52)	0	0
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	0	0
15. Phankuch rating (#24)	0	0
Hydrology/Streambank Subtotals	12	6
Overall Polygon Health Rating	39	23

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	Status Unknown

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category
Vegetation:	13 /	21 x 100 =	61.9%	Functional At Risk
Soils/Geology:	4 /	6 x 100 =	66.7%	Functional At Risk
Hydro/Bank:	6 /	12 x 100 =	50.0%	Nonfunctional (Unhealthy)
Total:	23 /	39 x 100 =	59.0%	Nonfunctional (Unhealthy)

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record: **9000015**

Click on the colored text to view the Pfankuch form for this record: **9000015**

ADMINISTRATIVE DATA

Record ID: **9000015**

Date field data collected: 6/25/96	Year: 96
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	06

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form? Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	3
3. Utilization of trees and shrubs (#34 & #35)	3	3
4. Shrub regeneration (#35)	3	3
5. Total canopy of woody species (#40)	3	1
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	3	3
Vegetation Subtotals	24	18
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	6	4
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	6
Soils/Geology Subtotals	12	10
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	6	6
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)		
15. Phankuch rating (#24)		
Hydrology/Streambank Subtotals	24	14
Overall Polygon Health Rating	54	42

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category	
Vegetation:	18	/	24 x 100 =	75.0%	Functional At Risk
Soils/Geology:	10	/	12 x 100 =	83.0%	Proper Functioning Condition (Healthy)
Hydro/Bank:	14	/	18 x 100 =	77.0%	Functional At Risk
Total:	42	/	54 x 100 =	77.0%	Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record:9000019

Click on the colored text to view the Pfankuch form for this record:9000019

ADMINISTRATIVE DATA

Record ID: 9000019

Date field data collected: 06/28/90	Year: 1990
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Lower Willow Creek	07

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	37E	31	SW	SE

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Murray Hill, Montana	Triple Crossing Reservoir East, Montana

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2342	Ephemeral Stream	2.76

Is PFC (health) evaluated with or without the Pfankuch form?	Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	1
3. Utilization of trees and shrubs (#34 & #35)	3	2
4. Shrub regeneration (#35)	3	0
5. Total canopy of woody species (#40)	3	2
6. Combined canopy cover of four lifeforms (#41)	3	1
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	0	0
Vegetation Subtotals	21	10
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	0	0
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	4
Soils/Geology Subtotals	6	4
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	2
12. Percent of bank vegetation altered by human-causes (#52)	0	0
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	0	0
15. Phankuch rating (#24)	0	0
Hydrology/Streambank Subtotals	12	6
Overall Polygon Health Rating	39	20

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	Status Unknown

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent	Descriptive Category
Vegetation: 10 / 21 x 100 = 47.6%	Nonfunctional (Unhealthy)
Soils/Geology: 4 / 6 x 100 = 66.7%	Functional At Risk
Hydro/Bank: 6 / 12 x 100 = 50.0%	Nonfunctional (Unhealthy)
Total: 20 / 39 x 100 = 51.3%	Nonfunctional (Unhealthy)

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORMClick on the colored text to view the Riparian Inventory Form for this record: **9000019**Click on the colored text to view the Pfankuch form for this record: **9000019****ADMINISTRATIVE DATA**Record ID: **900019**Date field data collected: **6/26/96** Year: **96**

State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	07

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form? **Without Pfankuch****POLYGON HEALTH EVALUATION****NOTE:** For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	1
2. Woody decadent and dead amounts (#31 & #35)	3	1
3. Utilization of trees and shrubs (#34 & #35)	3	3
4. Shrub regeneration (#35)	3	2
5. Total canopy of woody species (#40)	3	2
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	3	3
Vegetation Subtotals	24	17
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	6	4
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	6
Soils/Geology Subtotals	12	10
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	6	4
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)		
15. Phankuch rating (#24)		
Hydrology/Streambank Subtotals	24	12
Overall Polygon Health Rating	54	39

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent	Descriptive Category
Vegetation: 17 / 24 x 100 = 71.0%	Functional At Risk
Soils/Geology: 10 / 12 x 100 = 83.0%	Proper Functioning Condition (Healthy)
Hydro/Bank: 12 / 18 x 100 = 66.7%	Functional At Risk
Total: 39 / 54 x 100 = 72.0%	Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record:9000022

Click on the colored text to view the Pfankuch form for this record:9000022

ADMINISTRATIVE DATA

Record ID: 9000022

Date field data collected: 06/28/90 Year: 1990

State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	08

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	37E	27	SW	NE

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Collins Reservoir, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2293	Intermittent Stream	3.08

Is PFC (health) evaluated with or without the Pfankuch form? Without Pfankuch

POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	1
3. Utilization of trees and shrubs (#34 & #35)	3	1
4. Shrub regeneration (#35)	3	0
5. Total canopy of woody species (#40)	3	1
6. Combined canopy cover of four lifeforms (#41)	3	0
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	0	0
Vegetation Subtotals	21	8
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	0	0
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	4
Soils/Geology Subtotals	6	4
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	2
12. Percent of bank vegetation altered by human-causes (#52)	0	0
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	0	0
15. Phankuch rating (#24)	0	0
Hydrology/Streambank Subtotals	12	6
Overall Polygon Health Rating	39	18

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	Status Unknown

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category
Vegetation:	8 /	21 x 100 =	38.1%	Nonfunctional (Unhealthy)
Soils/Geology:	4 /	6 x 100 =	66.7%	Functional At Risk
Hydro/Bank:	6 /	12 x 100 =	50.0%	Nonfunctional (Unhealthy)
Total:	18 /	39 x 100 =	46.2%	Nonfunctional (Unhealthy)

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record: **9000022**

Click on the colored text to view the Pfankuch form for this record: **9000022**

ADMINISTRATIVE DATA

Record ID: **9000022**

Date field data collected: 6/26/96	Year: 96
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	08

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form?	Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	1
3. Utilization of trees and shrubs (#34 & #35)	3	3
4. Shrub regeneration (#35)	3	1
5. Total canopy of woody species (#40)	3	1
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	3	3
Vegetation Subtotals	24	14
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	6	4
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	6
Soils/Geology Subtotals	12	10
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	6
12. Percent of bank vegetation altered by human-causes (#52)	6	6
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)		
15. Phankuch rating (#24)		
Hydrology/Streambank Subtotals	24	16
Overall Polygon Health Rating	54	40

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category
Vegetation:	14	/	24 x 100 =	58.0% Nonfunctional (Unhealthy)
Soils/Geology:	10	/	12 x 100 =	83.0% Proper Functioning Condition (Healthy)
Hydro/Bank:	16	/	18 x 100 =	89.0% Proper Functioning Condition (Healthy)
Total:	40	/	54 x 100 =	74.0% Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record:9000024

Click on the colored text to view the Pfankuch form for this record:9000024

ADMINISTRATIVE DATA

Record ID: 9000024

Date field data collected: 06/29/90	Year: 1990
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	09

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	37E	19	NW	NE

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Collins Reservoir, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2229	Intermittent Stream	1.56

Is PFC (health) evaluated with or without the Pfankuch form?	Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	0
2. Woody decadent and dead amounts (#31 & #35)	3	2
3. Utilization of trees and shrubs (#34 & #35)	3	2
4. Shrub regeneration (#35)	3	3
5. Total canopy of woody species (#40)	3	2
6. Combined canopy cover of four lifeforms (#41)	3	0
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	0	0
Vegetation Subtotals	21	13
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	0	0
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	6
Soils/Geology Subtotals	6	6
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	2
12. Percent of bank vegetation altered by human-causes (#52)	0	0
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)	0	0
15. Phankuch rating (#24)	0	0
Hydrology/Streambank Subtotals	12	6
Overall Polygon Health Rating	39	25

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	Status Unknown

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category	
Vegetation:	13 /	21	x 100 =	61.9%	Functional At Risk
Soils/Geology:	6 /	6	x 100 =	100.0%	
Hydro/Bank:	6 /	12	x 100 =	50.0%	Nonfunctional (Unhealthy)
Total:	25 /	39	x 100 =	64.1%	Functional At Risk

PROPER FUNCTIONING CONDITION (PFC, or HEALTH) FORM

Click on the colored text to view the Riparian Inventory Form for this record: 9000024

Click on the colored text to view the Pfankuch form for this record: 9000024

ADMINISTRATIVE DATA

Record ID: 9000024

Date field data collected: 6/26/96	Year: 96
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State	BLM State Office	BLM District	BLM Resource Area
MT	Montana	Lewistown	Valley

Allotment	Area/Stream	Polygon No.
Willow Creek	Upper Willow Creek	09

Township	Range	Section	1/4 Section	1/4-1/4 Section
25N	35E	27	SE	SW

15. State Plane Coordinates		16. Universal Transverse Mercator (UTM) Coordinates	
Easting	Northing	UTM-X	UTM-Y:

17a. Quad Map 1	17b. Quad Map 2
Triple Crossing Reservoir West, Montana	

18. Elevation (ft)	19. Wetland Type	20. Polygon size (acres)
2625	Intermittent Stream	1.47

Is PFC (health) evaluated with or without the Pfankuch form?	Without Pfankuch
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POLYGON HEALTH EVALUATION

NOTE: For each item is given a "Possible" and an "Actual" score.

Vegetation Factors		
Health Form Item	Possible	Actual
1. Tree regeneration (#31)	3	2
2. Woody decadent and dead amounts (#31 & #35)	3	3
3. Utilization of trees and shrubs (#34 & #35)	3	3
4. Shrub regeneration (#35)	3	3
5. Total canopy of woody species (#40)	3	2
6. Combined canopy cover of four lifeforms (#41)	3	2
7. Total area occupied by noxious weed species (#43a)	3	3
8. Area occupied by undesirable herbaceous species (#44)	3	3
Vegetation Subtotals	24	21
Soils/Geology Factors		
Health Form Item	Possible	Actual
9. Amount of fine material present (#54)	6	4
10. Percent of polygon with human-caused exposed soil (#62b&c)	6	6
Soils/Geology Subtotals	12	10
Hydrology/Streambank Factors		
Health Form Item	Possible	Actual
11. Percent of streambank with active lateral cutting (#50)	6	4
12. Percent of bank vegetation altered by human-causes (#52)	6	6
13. Percent of streambanks with deep, binding root mass (#53)	6	4
14. Stream channel incisement (#61)		
15. Phankuch rating (#24)		
Hydrology/Streambank Subtotals	24	14
Overall Polygon Health Rating	54	45

16. Streambank Susceptibility Rating	Data for this rating not collected in 1989, 1990, and part of 1991
17. Trend Comments	

Rating Calculation:

Actual Score/Possible Score X 100 = Rating Percent				Descriptive Category	
Vegetation:	21	/	24 x 100 =	87.5%	Proper Functioning Condition (Healthy)
Soils/Geology:	10	/	12 x 100 =	83.0%	Proper Functioning Condition (Healthy)
Hydro/Bank:	14	/	18 x 100 =	78.0%	Functional At Risk
Total:	45	/	54 x 100 =	83.0%	Proper Functioning Condition (Healthy)

APPENDIX C

C1. Latitude and longitude location of each cross-section.

C2- C11. Cross-section measurements, widths and depths.

C1. Latitude and longitude location of each cross-section. RB-right bank, LB-left bank.

<u>cross-section</u>	<u>latitude</u>	<u>longitude</u>	<u>cross-section</u>	<u>latitude</u>	<u>longitude</u>
Sheepshed			Forest		
1RB	107.177678	47.885399	1RB	106.978344	47.888043
1LB	107.177835	47.885716	1LB	106.978824	47.888189
2RB	107.177006	47.884551	2RB	106.974483	47.890000
2LB	107.176793	47.884912	2LB	106.974218	47.890204
3RB	107.175032	47.884282	3RB	106.969925	47.889526
3LB	107.174810	47.884477	3LB	106.970283	47.889895
4RB	107.165915	47.886082	4RB	106.945921	47.888522
4LB	107.165699	47.886217	4LB	106.945917	47.889069
5RB	107.163448	47.886073	5RB	106.943773	47.889139
5LB	107.163104	47.886190	5LB	106.943905	47.889494
6RB	107.161168	47.884609	6RB	106.942093	47.890886
6LB	107.161090	47.884751	6LB	106.942583	47.891135
Camp			Collins		
1RB	107.091393	47.872399	1RB	106.910996	47.896336
1LB	107.091433	47.872545	1LB	106.911036	47.896470
2RB	107.092050	47.872245	2RB	106.909852	47.896458
2LB	107.092168	47.872439	2LB	106.909835	47.896595
3RB	107.089591	47.872644	3RB	106.906266	47.897299
3LB	107.089743	47.872834	3LB	106.906475	47.897273
4RB	107.077965	47.870857	4RB	106.887474	47.905129
4LB	107.077735	47.871022	4LB	106.887736	47.905054
5RB	107.077928	47.871482	5RB	106.882686	47.909358
5LB	107.077951	47.871751	5LB	106.883072	47.909694
6RB	107.071876	47.869626	6RB	106.879615	47.910039
6LB	107.071693	47.869870	6LB	106.879978	47.910319
Mudpot					
1RB	107.016072	47.869037			
1LB	107.016107	47.868807			
2RB	107.023576	47.865236			
2LB	107.023879	47.865419			
3RB	107.023195	47.865927			
3LB	107.023565	47.865951			
4RB	107.008899	47.874106			
4LB	107.008801	47.873964			
5RB	107.006761	47.874139			
5LB	107.006578	47.874122			
6RB	107.005310	47.874184			
6LB	107.005175	47.874315			

C2. Surveyed measurements, in feet, for cross-section profiles.

cross-sections above Sheepshed Reservoir					
1		2		3	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
3.33	0.09	20	-1.29	7.5	-0.71
12.67	-2.31	41	-1.67	11.58	-0.98
20.75	-6.56	70	-2.48	28.42	-1.83
32.17	-6.68	89	-3.73	41	-3.04
33.08	-8.35	92	-3.82	47.33	-4.83
34.5	-8.47	95	-3.6	51.25	-6
35.85	-9.66	104	-2.8	52.75	-6.4
37.97	-9.61	117	-3.27	53.83	-6.01
39.75	-9.67	124	-3.25	62.75	-5.15
42	-8.46	128	-2.11	76	-4
43.75	-8.68	135	-0.05	82.58	-2.9
44.97	-7.94	144	2.41	89.83	-1.26
64.47	-6.31				
99.33	-4.79				
117	-2.65				

C3. Surveyed measurements, in feet, for cross-section profiles.

cross-sections below Sheepshed Reservoir					
4		5		6	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
9.75	-0.4	13	-0.43	12.83	0.14
29.17	-0.57	22	-0.67	29.25	0.01
43.75	-1.59	29.75	-0.82	41.08	-0.48
44.5	-2.6	35.25	-0.45	52.67	-0.15
48.67	-2.95	43.33	-1.14	61.33	-0.51
50.97	-2.56	48.92	-2.07	71	-1.66
52.025	-1.67	49.67	-3.29	72	-1.68
55.85	-0.91	53.42	-4.22	73	-1.98
59.47	1.01	54.08	-4.28	74	-2.08
		54.83	-4.36	75	-2.07
		55.33	-4.46	76	-2.12
		55.92	-4.42	77	-2.1
		56.67	-4.54	78.58	-2.1
		57.5	-4.23	79.58	-2.1
		58.25	-2.31	80.58	-2.05
		67.75	-1.57	81.58	-1.76
		73.5	0.05	83.17	-0.33
				87.42	1.17

C4. Surveyed measurements, in feet, for cross-section profiles.

cross-sections above Camp Reservoir					
1		2		3	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
4.25	-0.24	13.25	0.24	16.75	0.28
13.33	-6.75	18.83	-0.87	25.33	0.19
21	-7.36	23.17	-3.21	28.42	-0.78
25	-7.75	27.17	-4.88	29.75	-2.14
26	-8.09	29.42	-5.95	32.58	-3.22
27	-8.23	32.17	-6.37	32.83	-4.02
28	-8.27	38	-6.44	35.42	-5.13
29	-8.47	42.75	-6.66	37	-5.43
30	-8.47	46.25	-7.53	38.58	-5.7
31	-9.15	49.83	-7.7	39.67	-5.78
32	-8.43	52.25	-7.97	40.83	-5.98
33	-8.23	54	-8.2	42.75	-5.83
34.08	-7.69	54.67	-8.48	44	-6.03
37.17	-6.53	55.17	-8.6	45.33	-6.2
47.67	-0.36	55.83	-8.54	46.83	-6.08
		56.42	-8.39	48.5	-6.1
		57.17	-8.14	50	-6
		58	-8.05	50.67	-5.78
		59.42	-7.59	52.92	-5.44
		61.17	-6	55.5	-5.4
		63.83	-5.04	60.17	-5.22
		70.92	0.04	63.42	-5.85
				68.17	-4.25
				74.17	-4.15
				80.83	-4.05
				84.5	-2.95
				89.92	-1.07

C5. Surveyed measurements, in feet, for cross-section profiles.

cross-sections below Camp Reservoir					
4		5		6	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
5.33	-0.68	11.5	-0.1	14	-9.99
16	-11.04	19.5	-3.3	23	-14.26
30	-13.24	35.58	-12.15	26	-15.16
38	-14.96	39.17	-13.85	30	-16.32
42	-15.06	43.17	-13.51	31	-17.38
44	-15.34	47.83	-14.45	32	-17.8
46	-15.58	50.92	-15.25	33	-17.86
48	-15.79	52	-15.86	34	-18.09
50	-15.88	53.17	-16.73	35	-17.86
52	-16.36	54.5	-16.95	36	-17.62
54	-16.77	55.7	-17.23	36.5	-17.06
56	-17.04	56.83	-16.7	37	-16.61
58	-16.45	59.08	-16	38	-16.5
59	-15.11	61.75	-16.18	39	-16.28
62	-13.98	64.17	-16.12	45	-14.75
78	0.6	65.67	-15.83	54	-13.25
		67.75	-15.73	61	-8.43
		69.17	-15.6	70	-1.3
		72.17	-15.32	120	1.81
		75.25	-15.11		
		79.75	-14.63		
		85.25	-12.65		
		99.67	-7.38		

C6. Surveyed measurements, in feet, for cross-section profiles.

cross sections above Mudpot Reservoir					
1		2		3	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
6.67	-0.29	16.75	0.17	16.83	0.26
15.67	-2.03	30.33	0.01	24.08	-3.4
33.08	-2.81	38.92	-2.22	24.67	-3.86
56.67	-3.86	43.25	-4.2	27.25	-4.63
60.5	-4.16	45.58	-4.67	30.08	-5.59
61.5	-4.2	46.75	-5.13	31.42	-6.25
62.5	-4.25	48.92	-5.4	32.42	-6.72
63.5	-5.04	49.58	-6.05	33.92	-7.75
64.5	-5.12	50	-6.33	34.92	-8.08
65.5	-5.01	51	-8	36.25	-7.85
66.5	-5.05	51.67	-8.13	37.5	-6.96
67.5	-4.78	52.6	-8.57	38.83	-5.5
68.5	-4.54	54	-8.5	44.17	-4.61
69.5	-4.54	55.33	-7.6	50.75	-4.3
70.75	-4.19	56.92	-6.28	61.75	-4
77.67	-1.81	57.17	-5.89	78.42	-3.68
84	-0.75	64.67	-5.01	88	-0.79
		72.58	-4.29		
		82.5	-3.95		
		86.5	-3.27		
		93.83	-0.12		

C7. Surveyed measurements, in feet, for cross-section profiles.

cross-sections below Mudpot Reservoir					
4		5		6	
0	0	0	0	0	0
7.08	-0.68	6.58	-0.53	7.42	-0.02
20.75	-4.64	13.08	-3.7	12.25	-1.74
36.25	-5.78	22.33	-5.8	16.33	-3.4
54	-6.43	46	-8.77	26.33	-11.2
62.42	-13.89	52.33	-14.39	28.5	-12.43
64.67	-16.32	57.67	-16.55	32	-14.37
70	-17.85	59.47	-17.51	33.83	-15.99
70.83	-18.79	61	-17.64	34.08	-16.38
71.58	-19	62.5	-17.41	34.5	-17.2
73.17	-19	63.75	-16.51	34.83	-17.76
74	-19.25	65.58	-15.62	36	-17.81
75	-19.28	68.97	-10.77	37.17	-17.59
76.25	-19.02	86.5	-10.13	39.08	-17.35
77.67	-18.2	95.33	0.6	40.58	-17.15
78	-16.93			41.42	-16.8
80	-15.75			42.42	-16.4
81	-10.13			43.33	-15
90.25	-10.36			46.92	-11.48
104	-9.45			56.33	-9.83
110	-1.41			66	-8.4
				76.33	-7.1
				89.25	3.55

C8. Surveyed measurements, in feet, for cross-section profiles.

Cross-sections above Forest Reservoir					
1		2		3	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
10.67	0.08	7.67	-0.33	6.50	-0.06
20.17	-5.71	15.50	-5.91	12.75	-5.08
40.67	-6.95	25.50	-6.56	15.00	-6.43
51.75	-7.97	26.67	-8.95	18.17	-6.94
52.92	-7.80	28.17	-10.19	21.25	-7.53
55.58	-9.75	29.83	-10.11	23.00	-8.33
59.58	-10.49	31.25	-11.73	23.17	-8.76
61.75	-10.77	32.83	-12.07	25.17	-9.37
65.00	-10.46	34.17	-12.03	26.42	-9.99
69.92	-9.59	36.50	-11.83	28.67	-10.43
73.67	-7.51	38.83	-11.73	30.75	-10.75
84.00	-7.21	40.67	-11.29	32.83	-10.60
100.25	-5.90	41.83	-11.15	34.5	-10.29
110.00	0.53	43.75	-10.67	37.00	-9.45
		46.50	-9.01	38.00	-8.80
		52.50	-7.35	41.17	-6.95
		69.17	-7.41	61.50	-5.88
		94.83	-6.19	100.00	-5.77
		100.00	0.05	174.00	-4.27
				210.00	0.65

C9. Surveyed measurements, in feet, for cross-section profiles.

cross-sections below Forest Reservoir					
4		5		6	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
11.00	0.24	6.5	0.34	9.25	-0.35
15.17	0.01	13.83	-3.99	16.58	-4
16.83	-2.87	18.25	-5.09	21	-4.95
30.33	-5.12	24.5	-4.57	36	-5.58
55.67	-6.19	32.67	-4.81	49	-7
93.58	-7.28	36	-9.14	53	9.68
104.25	-9.03	37.42	-10.26	56.67	-10.38
106.25	-10.84	37.92	-10.67	58	-11.18
107.25	-11.14	38.5	-11.1	59.25	-11.8
108.25	-12.26	39.67	-11.06	60.67	-12.05
109.25	-13.39	41.17	-11.77	61.75	-11.85
110.25	-13.44	43.25	-11.34	63.83	-11.15
111.25	-13.64	45.33	-10.76	65.92	-10.38
112.25	-13.38	46	-10.72	67.58	-8.04
113.25	-12.99	47.67	-10.34	69	-5.74
114.25	-12.79	49.58	-9.74	91.5	-4.91
115.25	-12.04	51.5	-8.94	120	-4.2
116.25	-11.39	52.58	-6.7	129	0.9
117.67	-10.96	76.17	-5.86		
119.25	-9.63	96.92	-5.82		
120.47	-8.06	128	-3.76		
125.33	-6.53	140	1.24		
135.17	-5.1				
142	-0.88				

C10. Surveyed measurements, in feet, for cross-section profiles.

Cross-sections above Collins Reservoir					
1		2		3	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
15.75	-0.01	12	0.01	9.25	-0.61
25.17	-0.02	13	-0.85	12.5	-2.28
26.25	-2.22	22.5	-4.23	15	-3.09
29.08	-3.34	25.17	-5.85	18	-6.93
31.92	-4.45	25.42	-6.35	19.5	-8.41
33.08	-6.72	27	-8.63	21	-8.92
36.58	-9.13	28.17	-9.21	22	-9.23
40.67	-9.75	29.5	-9.97	23.17	-9.94
46.08	-10.81	30.83	-10.71	25	-10.41
48.58	-10.11	31.83	-11.35	26.83	-11.1
53.25	-6.18	33.83	-11.83	29.75	-11.38
56.08	-3.61	35.83	-12.10	30.83	-11.61
59.08	-2.57	37	-12.00	32	-11.76
71.67	-1.08	38	-11.91	33.58	-11.95
73.75	0	39.33	-11.54	34.67	-11.89
		41.08	-10.98	35	-11.88
		42	-10.43	36.17	-11.60
		43	-9.64	37	-11.48
		44	-8.85	38	-11.34
		44.92	-7.74	39.08	-10.79
		46.5	-7.25	39.67	-9.68
		48	-6.35	40.33	-8.48
		50.67	-5.37	43.67	-5.48
		51.67	-3.41	48.67	-3.49
		57.75	-1.70	55	-0.84
		67.33	-0.5	66	-0.15

C11. Surveyed measurements, in feet, for cross-section profiles.

Cross-sections below Collins Reservoir					
4		5		6	
WIDTH	DEPTH	WIDTH	DEPTH	WIDTH	DEPTH
0	0	0	0	0	0
13.33	-1.36	20.67	-2.93	15	-7.84
20.75	-2.16	33	-3.92	20	-12.36
21.58	-3.22	51.92	-4.18	28	-14.43
25.17	-3.48	65.08	-5.15	44	-16.49
31.08	-5.40	68.83	-6.77	56	-19.46
38.67	-6.40	71.17	-7.83	73	-20.58
44.67	-5.44	73.08	-9.16	82.33	-21.43
49.67	-2.96	73.67	-9.55	84	-23.4
52.42	-1.78	74.58	-9.72	91.75	-24.25
52.83	-0.91	75.42	-9.83	93.17	-25.14
60.75	-0.62	76.75	-9.81	94.58	-26.34
65.92	-0	78.33	-9.67	96	-26.6
72.92	3.35	79.92	-9.64	97.5	-26.92
		81.25	-9.47	99.17	-26.77
		82.5	-9.21	101	-26.81
		87.33	-6.57	103	-26.72
		93.83	-5.42	105.17	-26.32
		99.5	-2.57	106.83	-25.1
				108	-24.27
				111.5	-23.47
				117.58	-21.83
				127.67	-15.98
				137	-0.51